THE ROLE OF S&T POLICIES IN NATURAL RESOURCES BASED ECONOMIES: THE CASES OF CHILE AND FINLAND

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THE ROLE OF S&T POLICIES IN NATURAL RESOURCES BASED ECONOMIES: THE CASES OF CHILE AND FINLAND

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To my lovely Teresita

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LIST OF SYMBOLS AND ABBREVIATIONS

S&T	Science and Technology
NRA	Natural Resources Abundance
R&D	Research and Development
OLS	Ordinary Least Square
GDP	Gross Domestic Product
LDC	Less Developed Countries
ISI	Import-Substitution-Industrialization
WWII	The World War II
OECD	Organization for Economic Co-operation and Development
SPC	Science and Policy Council
ICT	Information and Communication Technologies
NMT	Nordic Mobile Telephone
GSM	Global System for Mobile Communications
BIH	Basic Irrigated Hectares
NIS	National Innovation System
KAM	Knowledge Assessment Methodology
USTPO	United States Trademark and Patent Organization
CNIC	National Council of Innovation and Competitiveness
FNIC	National Fund of Innovation and Competitiveness
CORFO	Chile's National Development Corporation
MINECOM	Chile's Ministry of Economy
CONICYT	Chile's National Commission of Science and Technology

MINEDUC	Chile’s Ministry of Education
FIA	Chile’s Agrarian Innovation Fund
MINSALUD	Chile’s Ministry of Health
MIDEPLAN	Chile’s Minister of Planning and Cooperation
ICM	Millenium Scientific Initiative
FIP	Fishing Innovation Fund
PCT	Science and Technology Program
PIT	Technological Innovation Program
PDIT	Program of Development and Technological Innovation
PBCT	Science and Technology Bicentenary Program
FONDECYT	Fund for Scientific and Technological Development
FONDEF	Fund for Fostering Scientific and Technological Research
FONDAP	Fund for Advanced Research in Priority Areas
VET	Vocational Education Training
STPC	Science and Technology Policy Council
MINEDU	Finland’s Ministry of Education
MTI	Finland’s Ministry of Trade and Industry
TEKES	Finland’s National Technology Agency
SITRA	Fund for Research and Development
VTT	Technical Research Center
TEKEL	Finnish Science Park Association
EEDC	Employment and Economic Development Center
CEP	Center of Expertise Program
TFP	Total Factor Productivity
EAP	Economic Active Population

SUMMARY

The study presents an analysis of the role of science and technological (S&T) policies in natural resource-based economies, focusing on the cases of Chile and Finland. The exploitation of natural resources has been identified by several authors as a limited-long-term factor that affects economic growth. Finland following a technology-intensive path has combined natural resource abundance (NRA) with high growth rates. On the other hand, Chile whose economy depends mainly on NRA industries such as mining and forestry has not attained the Finnish economic level in spite of the successful reforms undertaken during the last two decades. Using analytical tools I define the S&T contribution to national income per capita over the 1981-2000 period, and analyze the complementarity of the relationship between S&T expenditures and NRA in both countries. I explain the diverging S&T performances in lights of three factors: institutions, education, and decentralization

CHAPTER 1

INTRODUCTION

Natural resource abundance (NRA) has been at the center of an intensive and steady debate during the last decades. Is it a real “curse” deterring NRA countries from economic growth or a development catalyst once some conditions are fulfilled? Several examples may support both positions. Australia, Canada, the United States and the Scandinavian countries have been cited as successful cases of nations which have built their richness over NRA (De Ferranti, 2002). On the other hand, Latin America and Africa may be defined as counterexamples in which the absence of complementary factors such as a property rights system, education and learning capacity has deterred them from fruitful natural resources exploitation (Lane and Tornell, 1996; Deaton, 1999; Maloney, 2002).

The divergence of NRA-countries’ performances noted through the twentieth century may be emphasized by analyzing the cases of Chile and Finland. Since the mid-nineteenth century, Chile has based its economy on the exploitation of natural resources with mining as its main economic activity. Such natural resources dependence is still a major feature of the Chilean economy as its current share of primary goods exports in total exports confirms (Eyzaguirre, 2005). On the other hand, at the turn of twentieth century, Finland was identified as an agricultural-based economy with a high dependence on Russia and Sweden (Blomstrom, 1991). At the time, the income per capita gap between the two countries was not significant, although Chile outperformed Finland during most part of the first half of the century (Maddison, 1995). However, such low difference would be left behind. The adoption of several policies, regarding trade liberalization, innovation and learning capacity led to a significant modification of the Finnish productive structure transforming Finland into a competitive and knowledge-based economy (Schienstock, 2005). Chile lagged behind regarding the implementation of such policy reform leading to the emergence of an increasing economic gap between both countries during the second half of the twentieth century as their current income per capita performances confirm[1].

The thesis focuses on a comparative analysis for the cases of Chile and Finland regarding the role and effect of Science and Technology (S&T) policies on national economic growth. With that aim, I explore the economic development of both countries, presenting the factors mentioned in the literature as the major causes of the differing development paths of Chile and Finland. I devote special attention to comparing innovation performances using input and output indicators, especially those coming from the World Bank KAM Index[2]. In order to define the R&D contribution to economic growth, I use an Ordinary Least Squares (OLS) with robust standard errors covering the 1981-2000 period, expanding normal growth regression using explanatory variables regarding NRA and R&D. I test two hypotheses. Firstly, I suggest that R&D contribution to national income per capita has been higher in the case of Chile than Finland

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[1] Chile GDP per capita-2005: $5,747 (2000 US$)
Finland GDP per capita-2005: $25,591 (2000 US$)
World Development Indicators, The World Bank

[2] The KAM was designed by the Knowledge for Development Program to proxy a country's preparedness to compete in the knowledge economy using more then 80 structural and qualitative variables. The comparison is undertaken for a group of 128 countries, which includes most of the OECD economies and more than 90 developing countries (see Science, Technology and Innovation topic in World Bank website www.worldbank.org)

(Hypothesis 1). Secondly, I predict that NRA has been a stronger complement of R&D in the case of Chile than Finland (Hypothesis 2). Stating both hypotheses takes into account previous work on the effect of R&D investment on economic growth suggesting that the returns to R&D in developing countries are above those of industrialized countries (Lederman and Maloney, 2003; Goal and Ram, 1994). Worth to note is that high and increasing levels of both R&D expenditures and human capital, solid institutions, a steady and fruitful public-private interaction, and the emergence of strong regional innovation systems are cited as key factors behind the technological Finnish success (Schienstock, 2005).

The thesis is organized as follows. In the remainder of the first chapter, I discuss previous works on NRA return to economic growth. The second chapter focuses on the historical economic development of the two countries. I looked for the major factors which have led Finland to outperform Chile nowadays, mainly import-substitution-industrialization (ISI) policies, land reform and innovation capacity. In the third chapter, I present the analytical model used to undertake the empirical analysis. I discuss its results, focusing on three categories: institutionalization; education, and decentralization.

1.1 Natural Resource Abundance

Exploring the impact of NRA in economic growth the concept of Dutch Disease has been set up. Coined as a term by The Economist in 1977[3] as a description of the decline of the manufacturing sector in the Netherlands after the discovery of North Sea oil in 1970, its theory states that an increase in revenues from natural resources will de-

[3] The Dutch Disease" (November 28, 1977). *The Economist*, pp. 82-83.

industrialize a nation's economy by raising the exchange rate which makes the manufacturing sector less competitive. Developed by Corden and Neary (1982) the Dutch Disease model divides the economy in three categories: a non-traded sector (services), and two traded sectors, a booming or tradable natural resources sector (oil, gas, mining, crops), and a lagging or tradable non-resource sector (manufacturing). It states that the greater the NRA, the higher the demand for non-tradable goods, shifting away labor and capital from the manufacturing sector.

Following up the Dutch Disease statement, several authors have deepened the discussion. Matsuyama (1992) has provided a formal model of the "linkage approach", exploring the role of agriculture productivity in economic development granting learning-by-doing feature to the manufacturing sector. His model is characterized by two sectors: agriculture and manufacturing. He comes to the conclusion that forces that push the labor force away from manufacturing and toward agriculture lower the growth of the economy by reducing the learning-induced growth of manufacturing. Besides, he points out that trade liberalization in land-abundant economies may slow growth performance by leading to resource shift from manufacturing towards agriculture.

Sachs and Warner (1995) show that economies with a high ratio of natural resource exports over GDP in 1971, have lower growth rates over the 1971-1989 period. The trend holds even after controlling for important growth variables such as initial per capita income, trade policy, government efficiency, investment rates and other variables. Mainly, they state that 1-standard-deviation increase in natural resources exports as fraction of GDP would lead to 1 percent point per year slower rate of growth. However, it is worth noting that despite the negative relationship between NRA and economic growth the authors define as a mistake subsidizing or protecting non-resource-based sectors as a basic strategy for growth. In further studies, both scholars revisit the topic, reinforcing their prior conclusion by changing the base year to 1970 and by extending the dataset by one year to 1990 (Sachs and Warner, 1997), and by analyzing the role of geographical or climate variables and by answering whether there is a bias resulting from some other unobserved growth deterrent (Sachs and Warner, 2001).

Other studies support the Sachs and Warner NRA-negative relationship with growth performance. Gylfason et al. (1999) grants the fact that natural resource sectors create and need less human capital than other productive sectors, concluding that "an increase in either the share of the primary sector in the labor force or in the share of the primary exports on total exports from 5 to 30 percent from one country or period to another reduces per capita growth by about 0.5 per cent per year".

What kind of factors can be behind the harming-growth feature of NRA stated by the authors so far mentioned? De Long and Williamson (1994) notes that when a natural resource has high transport costs, then its physical availability within the economy is essential for the introduction of a new industry or a new technology. He cites the case of coal and iron ore deposits as prerequisite for the development of indigenous steel industries in the late nineteenth century. Lane and Tornell (1996) hold an explanation based on a "feeding frenzy" which starts with a windfall coming from either an improvement of terms of trade or the discovery of a new natural resource source which leads to a strong rent-seeking competition among power groups ending up in an inefficient exhaustion of public goods.

Stijns (2005) argues that once a natural resource boom starts out, developed countries are in better shape than less developed countries (LDC) to face the challenge of NRA exploitation due to the well-defined and well-functioning property rights systems ruling the latter which contrast sharply with the weak and dysfunctional LDC economic policies. He states that in the LDC case, a natural resource boom may lead to wasteful rent seeking process and possible rising inequality. Deaton (1999) cites as the main problems in the specific case of African countries the low quality of investment, low processing level of exports, high concentrated mineral ownership, and the absence of complementary factors, particularly education.

However, several authors have stated that NRA not necessarily is a deterrent of growth performance. The cases of Australia, Canada, USA and Scandinavian countries do not confirm the rule of the "natural resource curse". In his long-run comparison of mineral-based and non-mineral based countries performances, Davis (1995) concludes that mineral-based countries outperform non-mineral countries. The negative effect of NRA pointed out by the authors already mentioned may be offset by other factors such as human capital and innovation capacity. De Gregorio and Bravo-Ortega (2005) argue that the negative effect of NRA on growth may be outweighed by high levels of human capital. Their results indicate that NRA reduces economic growth in countries with low levels of human capital. Even more, they note that human capital not only partially compensates for NRA negative effects but may more than offset them. They point to the case of Scandinavia as an example of how countries that are well-endowed with human capital may reach high growth rates through a simultaneous synergetic development of a natural resource industry and a high technology sector.

Maloney (2002) identifies barriers with deep historical roots to technological adoption and innovation as the causes of Latin America's underperformance, mainly a deficient "learning capacity" which has been intensified in the postwar period by the implementation of import substitution policies. He notes that strengthening local human capital, reaching high literacy rates or promoting technical education, has reinforced the developed countries capacity to learn from what was happening abroad, accessing quickly to knowledge generated abroad, and, in the long run, establishing local clusters. Lederman and Maloney (2003) using a cross-country analysis show that NRA is positively correlated with growth, and that Research and Development (R&D) investment and NRA are strong complements: the returns to R&D rise with natural resources exports and vice-versa. De Ferranti et al. (2002) reinforce the assessment of NRA role according to endogenous capabilities, promoting engendering a high level of human capital and developing capacity for national learning and innovation.

Summing up, complementary factors may put NRA countries out of the "curse" path. NRA countries with high level of human capital, well-defined property rights systems, stable and homogenous economical-political system, and steady R&D investment, may transform their NRA into an important booster of its growth performance.

CHAPTER 2

CHILE'S AND FINLAND'S ECONOMIC DEVELOPMENT

Chile and Finland have shared a common feature, NRA. Mining in the case of Chile, and agriculture and forestry in the case of Finland have been strategic engine growth and good examples of how NRA may set up industries with significant socio-economic returns. However, despite their NRA, both countries have followed different economic paths with different outcomes. The current chapter aims to review the economic development of Chile and Finland in order to identify which have been the major factors which have shaped the diverging economic performances of both countries. The differences that will be discussed will not be explained by superficial, short-term variables, but by deep-seeded socio, economic, and political factors that have defined the principle characteristics of their economic performances. In order to identify the mayor factors which justify the divergence of the Chilean and Finnish economic performances, I base my analysis on prior works developed by several scholars regarding comparison analyses between Scandinavian and Latino American countries.

Blomstron and Meller (1991) group the causes of the Scandinavia and Latin America divergent performances into six factors: natural resources and industrialization, trade and industrial policy, socio-political aspect and the role of the state, agrarian reform, education, and foreign technology and capital. Both Regions faced Industrialization using differing strategies. Whereas Scandinavian countries built their current productive structures promoting a steady upgrade of both manpower skills and mechanization processes involved in the exploitation of their natural resources wealth, Latin American countries opt for an industrialization process mostly focused on non-natural resources-based activities[4]. Such premise led the latter to ending up with productive structures similar to those of developed countries[5] which were not only non-affordable by the weak Latin American economies but postponed the value-added quest within natural resources industries. With regard to trade and industrial policy, Blomstrom and Meller (1991) point out that prior to the Great Depression, Latin America and Scandinavia were regions fairly open for trading. Nevertheless, the economical shock led them to diverging trade strategies. Whereas Scandinavia remained open, despite a short closing-period in Finland, Latin America decided to substitute their imports and to close their economies by targeting self-sufficiency as its main economical goal (Bravo-Ortega, 1999). In addition, the fact that Latin American governments were directly involved in goods and services production reinforced the closeness of their national economies contrasting sharply with the role of infrastructure and social service suppliers, out of productive activities, of Scandinavian governments.

Blomstrom and Meller mention land reform as another cause of the diverging performances of Scandinavia and Latin America. According to them, land reforms in Scandinavia created "small and medium-sized, privately-owned farms" which led to more efficient land cultivation allowing not only a higher investment, but also an increasing innovation rate. By comparing both reforming processes, timing and political

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[4] As natural resources industries were mostly owned by foreign investors, Latin American national authorities did not perceived them as economical tools under "national management" deterring them from being used for the national development goals achievement.

[5] Blomstrom and Meller (1991) highlight the case of Ecuador which had almost as many car producers than the US in the 1960s.

environment come along as key factors. Most of the Scandinavian countries had implemented land reforms during the first decades of the twentieth century, whereas in most of the Latin America countries it did not come until the 1960s or 1970s (Bravo-Ortega, 1999). On the other hand, the lack of general political support in Latin America mainly due to ideological struggles contrasted drastically with the social consensus supporting land reforms in Scandinavia (Haavisto and Kokko, 1991).

Education and foreign technology are cited by Blomstrom and Meller as part of the pool of causes behind the Scandinavia and Latin America diverging performances. De Gregorio and Bravo-Ortega (2005) emphasize such rational by pointing to the Scandinavian achievement of high literacy rates early on the twentieth century, with Latin America lagging far behind at the time[6]. It is worth to note that such historical divergence has not been only limited to literacy but it has rather extended to primary, secondary, and tertiary enrollments leading to major differences in high-skills workers supply affecting the emergence of new industrial activities. In addition of human capital, the commonly innovation granted role of growth catalyst (Lederman and Saenz, 2005) may be confirmed by analyzing the Scandinavia-Latin America gap. Exploring the cases of Finland and Chile may help to illustrate such situation. Not citing any innovation-development causality for such specific cases, it is worth to note that Finland has defined knowledge as the main engine of its economy affording it a new phase of development by

[6] Literacy rate 1870-1890
Chile : 30.3%
Finland : 89%
Chile from Engerman, Mariskal and Sokoloff (1997)
Finland from O'Rourke and Williamson (1995)

means of higher levels of competitiveness (Schienstock, 2005). Jumping into the Knowledge Economy afforded Finland a significant shift of its productive structure leaving behind its natural resources dependence by replacing it with a high-tech focus (Dahlman et al, 2005). On the other hand, Chile has not undertaken a similar process yet. Its innovation indicators despite of being rank among the highest among developing countries are still far behind of Finland's, situation which has led to identify its innovation capacity as one of the most important barrier of Chile's development (The World Bank, 2003; OECD, 2005).

The chapter is organized in three sections. First, a brief overview regarding two economic indicators: a) income per capita measured as Gross Domestic Product (GDP) per capita, and b) share of natural resources exports in total exports. The use of such indicators is aimed to show how diverging have been the Chilean and Finnish economic performances, and how primary goods dependency has evolved with regards to economic growth in both countries. Second, a descriptive section focused on the historical economic development of Chile and Finland covering the last decades of the nineteenth century and the twentieth century. Third, I display a section regarding the analysis of three of the causes of the diverging performances: import-substitution-industrialization, land reform and innovation capacity.

2.1 Income and Natural Resources

Nowadays, the gap between Chile and Finland regarding GDP per capita is significant. Whereas Chile had an income per capita of $5,747 in 2005, Finland had one of $25,591[7]. Therefore, Finland quadruplicates Chile. However, the situation was radically different a hundred years ago. According to Maddison (1995), the dawn of the twentieth century found Chile and Finland with similar incomes per capita, with Chile outperforming Finland during most part of the first half of the century (see Figure 1). Even more, De Gregorio and Bravo-Ortega (2005) point out that Chile's GDP grew at a rate of 2 percent between 1870 and 1913 whereas Finland did at 1.4 percent, so that Chile's performance was higher not only in absolute terms but also in growth terms.

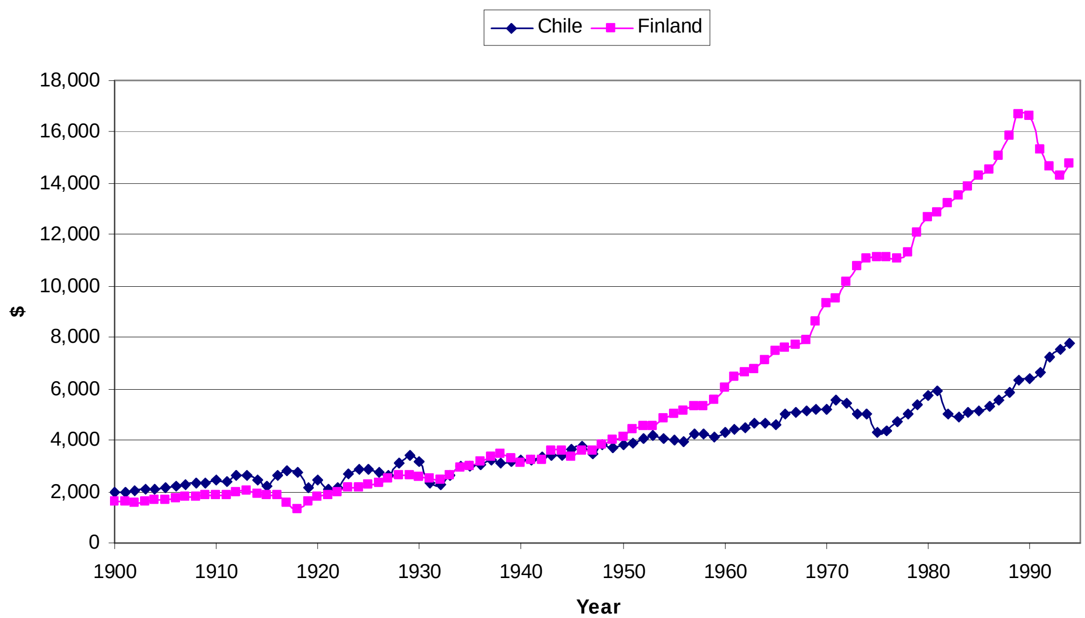

Figure 1: GDP per capita 1900-1994
Source: Maddison (1995)

[7] World Development Indicators, The World Bank (constant 2000 US$)

Nevertheless, Chile's outperformance did not hold along the twentieth century. After the World War II, Finland started a period of steady growth which led to an increasing income gap between the two countries. Such divergence has been accompanied by structural changes in the Finnish economy. As Graph 2 shows, Finland has reduced its share of natural resources exports in total exports from 30 percent during the earlier 1970s to 14 percent at the upper 1990s, whereas Chile has performed over 80 percent during the same period (see Figure 2).

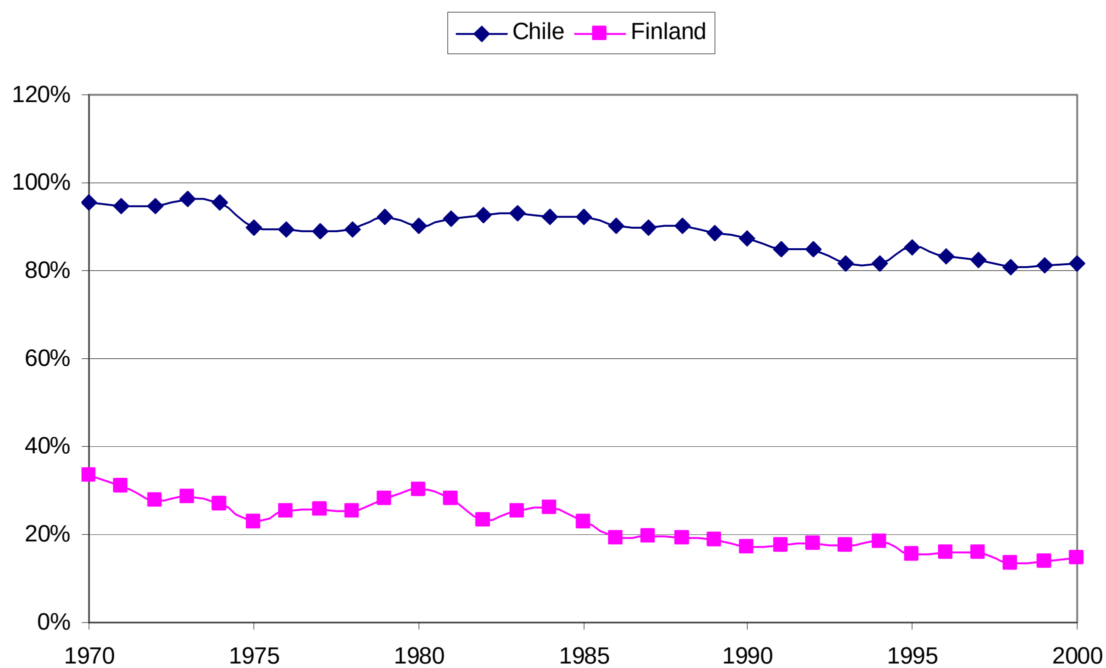

Figure 2: Natural Resources Exports/Total Exports 1970-2000
Source: United Nations Statistics Division
Commodity Trade Statistics Database (COMTRADE)

At the same time, Finland's share of high tech exports in manufactured exports has increased from 8 percent in 1990 to 21 percent in 2004, whereas Chile has performed under 5 percent all along the period[8]. In the case of Finland, the GDP per capita's increasing trend is concurrent with both the decreasing pattern regarding the share of natural resource exports in total exports and the increasing behavior of the share of high tech exports in manufactured exports. In the case of Chile, such concurrency is not replicated. The much slower growth of Chile's GDP per capita is concurrent with high levels of the share of natural resource exports in total exports and with a stagnant performance regarding high tech exports. Summing up, Finland's better economic performance coincides with a significant change in its productive structure by replacing its older focus on primary goods production by a new one of high tech products commercialization. At the same time, the absence of change in Chile's productive structure, reinforcing the historical natural resources dependency of its economy, coincides with a slower growth rate than Finland's during the second half of the twentieth century.

2.2 Economic development review

2.2.1 Chile

In his 1880-1990 review of Chilean economic development, Meller (1991) divided his analysis in the three chronological sections: nitrate and copper; industrialization; and economic liberalization.

[8] World Development Indicators, The World Bank

2.2.1.1. Nitrate and Copper

According to Meller (1991), natural resources have always played an important role in Chilean economy. During the sixteenth century, gold and silver were major resources. During the eighteenth and the nineteenth century, wheat was important. However, since the second half of the nineteenth century, two resources have linked Chile to the world economy: nitrate and copper.

Located in the northern regions of Tarapaca and Antofagasta, nitrate mines afforded significant revenues for the Chilean economy, becoming the sector the most important source of foreign exchange and government revenues. According to Mamalakis (1976) from 1900 to 1930 more than 50 percent of total government revenues were financed out of nitrate exports which jumped from \$6.3 million in 1880 to \$70 million in 1928, peaking at \$96 million just before World War I, being the GDP share of nitrate exports about 25 percent between 1900 and 1920 (Meller, 1991). The nitrate boom led the sector to become a major employer by rising its labor force from 4,500 in 1886 to 60,800 in 1925 and never falling below 43,000 during 1910-20 (Mamalakis, 1976). Cariola and Sunkel (1985) argue that the explosive growth of the nitrate activity was not only an "enclave" in the Chilean Northern regions but generated a significant answer from Chilean entrepreneurs by means of the emergence of a vast pool of supplying firms. Unfortunately, the development of synthetic nitrate and the Great Depression took the industry through a swift fall affecting hardly not only the sector itself and its related-industries but the whole Chilean economy.

TABLE 1 Statistics US multinational copper companies in Chile 1945-1965

PERIOD	Annual Return On Assets (%)		Investment (Mill $)	
	Chile	Worldwide	Chile	Worldwide
1945-1950			35	195
1950-1955	19.0	9.0	115	344
1955-1960	25.9	9.5	168	519
1960-1965	14.8	4.8	82	422

Source Meller (1991)

Concurrently with the emergence of the nitrate industry major mining flows started out around another mineral: copper. In this case, Meller cites two major events which transformed the copper industry: 1) a increasing demand due to the new electricity industry and the expansion of the construction sector, and 2) the feasibility of obtaining profit gains from the large-scale exploitation of ore with low copper content due to a new technological innovation at the time. As in the nitrate, copper extraction was carried out by external agents: U.S. investors. In 1945, copper exports made up over 50 percent of total exports, and close to 60 percent between 1955 and 1959. In lights of the significant revenues obtained by US investors and their low investment rates regarding international averages (see Table 1), Chilean authorities started to question whether the goals of US firms met the development goals of Chile. Finally, as disagreement between U.S. companies and the Chilean government increased and local copper capacity emerged, the government decided to nationalize the copper mines, which resulted in the complete takeover of U.S. companies in 1971.

2.2.1.2 Industrialization

Referred to as the "Industrialization Era", the 1934-73 period was characterized by a profound transformation of the Chilean development pattern by jumping into an inward–oriented strategy leaving behind the outward-strategy promoted during the nitrate boom period (Eyzaguirre et al, 2005). Such phenomenon was an outcome of how violent the Great Depression shocked the Chilean economy[9] -exports down by 90 percent and national income by half (Maloney, 1997)- stemming the questioning of the fruitless of having an economy depending on external factors and putting in motion populist forces whose challenging demand elicited a flow of social instability. Facing up a so dire economical fall, Chilean authorities decided to promote industrialization by making Import-Substitution-Industrialization (ISI) the focus of its development strategy. ISI policy implementation was carried out through enacting high tariff protection, special incentives for the manufacturing industry through low credit and special access to foreign exchange, and public investment in infrastructure targeted to complement industrial production. According to Velasco (1994) ISI presented two faces. On one hand, particularly during the 1930s an 1940s, the social alliances and distributional mechanisms related to it afforded some growth and industrialization, and most of it deterred Chile from being a locus of social struggles. In Velasco (1994, p.380) words "…they (ISI policies) also proved capable of ensuring a modicum of social mobility and preventing social pressures from boiling over. As a result, Chile was an island of stability from 1930s to the late 1940s…". Nevertheless, Velasco notes that as ISI implementation

[9] Velasco (1994) cited a League of Nations report identifying Chile as the hardest hit of any country

advocated for excessive regulations, a tax system filled with special regimes and exception, and an increasing public spending, budget deficit and inflation did not take long to show up. Eyzaguirre et al (2005) point to the small size of the national market, the no integration of the Latin American markets, the lack of export incentives, and the continuing dependence on imported capital goods as factors that led to a stagnant economical phase. What were the ISI effects for Chilean national economy? Meller (1991) cites two both negatives: 1) the overall GDP performance was still considered unsatisfactory, as increases in domestic productivity were very low[10]; and 2) the economy had a relatively slow incorporation rate of modern technology into its productive sectors.

2.2.1.3 Chile's Economic Liberalization

In the mid-1970s, the Chilean economy shifted from a strong state-controlled , and a closed economy to a free-market and a fully-liberalized economy. Once the 1973 military coup, the Pinochet's government opt for applying a radical change on the economic model ruling Chile at the time. The private sector was singled out as the new engine of the national economy, with an exclusive participation on the goods and services production, particularly on natural resources export activities. The task was undertaken through the elimination of price control and subsidies, and the liberalization of the finance and trade markets. As a result, the export share of GDP increased from 12 percent in the 1960s to more than 27 percent during the 1980s (Meller, 1991), and the budget deficit inherited from the Unidad Popular Administration was overcome. At a first

[10] GDP per capita grew at average yearly rate of 2.1 percent during the 1934-73 period (Eyzaguirre et al, 2005)

privatization round most of state-owned enterprises were sold, staying under public control just 43 firms far down of the more 500 hundred existing by the end of the Unidad Popular government in 1973 (Velasco, 1994). Nevertheless, according to Eyzaguirre et al (2005), a constant and sustainable growth was not achieved mainly due to an unsuitable macroeconomic management and to an insufficient regulation of the financial market. In addition, pursuing to minimize the role of the state led to a dire deterioration of the actual social conditions and of the physical and social infrastructure. Such failures, particularly the weak finance market regulations, elicited the 1975 and 1982 economical crises with GDP per capita falls of 13 and 15 percent respectively.

After the 1982 crisis both the macroeconomic management and financial market regulation failures were corrected, allowing a recovery of the national growth rate[11] and steady improvement in the external accounts. According to Velasco (1994) the latter was the result of a combination of internal and external factors: the government reshaped the outward-oriented strategy aiming to restore economic growth through exports, specially through non-copper exports, and to continue servicing the external debt, unlike its Latin American neighbors whose rejection of paying their international loans led them to complex socio-economical situations. Nevertheless, despite its macroeconomic success, the persistence of the state role minimization still deterred Chile from having high levels of equity; social spending on education and health decreased, whereas unemployment and poverty grew (French Davis, 2003).

[11] GDP per capita grew at an average yearly rate of 4.6 percent during the 1985-90 period (Maddison, 1995)

The advent of a democratic government represented a significant momentum to Chilean social development, mainly characterized by the implementation of new social programs that benefited Chile's poorest population. As expected, by maintaining both the active role of the private sector and the set of institutions inherited from Pinochet's government, the democratic administration did not modify the main orientation of the economic system. Chile succeed on achieving high growth rates by reaching an annual average rate of 7.7 percent during the 1990-97 period, and on reducing the rate of poverty falling from 45 percent in 1989 to 18 percent in 2003 (French Davis, 2003). However, the Asian crisis strongly affected the Chilean economy, its average growth rate declined to 2.5 percent during the period 1998-2002. Despite a recovery during the subsequent period, several studies stated that lack of innovation would be a serious barrier to the future Chilean growth performance, deterring the country from technology creation and adaptation, and from the achievement of being a developed nation (The World Bank 2003, OECD, 2005).

2.2.2 Finland

In their historical Finland's economic development review, Haavisto and Kokko (1991), identify Finland as the poorest European country of middle nineteenth century. Its dominant economic activity at that time was agriculture, with farmers mainly focused on animal husbandry and dairy production. They remark the major role played by Russia as Finland trade partner which allowed a significant increase of the agro-activities, leading butter to be an important export product accounting for 20 percent of exports at the turn of the twentieth century. However, the economic situation turned down as small Finnish farmers could not follow the technology path due to its high costs at the time, being the returns concentrated on the major landowners. Inequality increased pushed by a rising unemployment and a significant migration to rural areas.

Time was short to reach an explosive situation. The increasing discontent led to the emergence of a large rural proletariat which found its place under the umbrella of a more progressive political party: The Social Democrats. In 1916, Social Democrats took over the national government, fact followed quickly by an Independence Declaration promoted by right-wing parties with the support of Germany and Sweden, fearful not only of the progressive ideas of Social Democrats but specially of the spread of the Bolshevick Revolution. Finally, the polarization led to a Civil War which ended up with the right wing forces victory. Despite their victory, the right wing forces were aware of their weak political position, stemmed from unsolved socio-economic problems. Haavisto and Kokko states that such rational led them to institute two land reforms whose premises gave rise to a major change in rural population: tenant farmers almost disappeared, and the number of landless rural laborers decreased significantly.

With the end of The World War II (WWII), the question of whether Finland would catch up its Scandinavian neighbors came up in light of its decision of staying outside the Marshall Aid program, the burden of supplying war reparations to the Soviet Union, and the continuing strong support to agriculture, in addition to the destruction of large parts of the capital stock. According to Haavisto and Kokko several factors collaborated to turning down such pessimistic scenario, pushing Finland not only to catch up its neighbors but throwing it into the wealthiest countries league. First, an erosion of the rural bias ruling Finnish economy at the time came up. One of the outcomes of WWII for Finland was the loss of Karelia Region to the Soviet Union which represented 12 percent of total national territory at the time. In order to resettle Karelian refugees the Finnish opt to support agriculture activity through controlling prices and distribution. However, the farmer's demand for higher prices and the urban worker demand for higher wages pushed the authorities to modify their initial strategy by enacting a subsidy system aimed to support farmer activities and constraints on consumer prices. Haavisto and Kokko note that as an outcome of such strategy the agriculture labor productivity growth remained under 3 percent per year during the 1946-60 period, whereas labor productivity in industry grew at a 5 percent yearly rate. Such phenomenon brought the government to prefer larger production unit and more efficient method of production in light of significant budget pressure due to high number of Finnish small farmer existing at the time. Concurrently, a strong migration phenomenon occurred. As long as mechanization was being promoted and increased among farmers, particularly since the late 1950s, the demand for rural labor decreased eliciting major flows of workers heading towards urban areas looking for better opportunities. Worth to note it is the significant amount of Finnish who migrated to Swedish: over 200,000 people mostly younger migrated to Sweden between 1960 and 1970 (Haavisto and Kokko, 1991).

The second key factor on the post-WWII Finnish economical rise was the implementation of an economic recovery program aimed to rebuild the productive capacity and infrastructure of Finland. Primarily driven by meeting the Soviet Union repairing demand and the resettlement of Karelian refugees, industrial capacity recovery received top priority. Haavisto and Kokko cite the development of the metal industry and the restoration of the power productivity capacity as major example of the achievement of economic recovery plan goals. In addition, a report by the European Regions Research and Innovation Network (ERRIN, 2005) points out how nowadays strong export-oriented industries such as pulp and paper and basic chemicals throve at the time thanks to the heavy investment of the post-industrialization process. Thereby the GDP share of industry exceeded the share of the primary sector for the first time in 1949, moving away Finland's economical structure from its prior rural bias.

In addition to the factors already mentioned, Finland's strong postwar relationship with the Soviet Union also affected its economic development to a great extent. Because 15 to 25 percent of its total exports went to the Soviet Union, Finland was the most important Soviet Western trading partner until the end of the 1960s and again in the 1980s (Schienstock, 2005). The two countries, in 1948, signed the Treaty of Friendship, Cooperation and Mutual Assistance, a five-year agreement that ensured the exchange of goods that adhered to strict payment and price principles. Nevertheless, despite the dynamic trading relationship with the Soviet Union, Finland remained during the first post-WWII decade as closing economy. The liberalization of trade did not come up until 1955 by starting to decrease gradually tariffs and by relaxing quotas fixation . Several trade agreements were signed leading Finland to reach European policy trade standards by 1960s. Such trade progress put Finland facing the challenge of export competitiveness. By the early 1980s, the export share of the value added in primary and secondary sectors represented 80 percent, up from 60 percent by the 1960s[12]. Haavisto and Kokko argue that at least until the late 1960s, Finland's economy was mainly boosted by policies

[12] Haavisto and Kokko cite Hjerppe (1988)

aiming to achieve growth, investment, and particularly the international competitiveness of its exports.

The question of increasing export and the whole economy competitiveness pushed key social actors in the business or the public sector to conclude that Finland should no longer base its economic development on cost efficiency but rather on knowledge and technology intensity (Schienstock, 2005). Leaving behind the resource-driven label of the early 1970s Finnish economy and replacing it by a knowledge-driven one came up as the key challenge to be answered in order to support Finnish companies struggling in an increasingly competitive global economy. To achieve such goal, Finland kicked off a long policy reform process aimed to provide the right incentives for achieving an increasing R&D investment rate. The strategic decision of defining innovation and knowledge as major development goals and of taking up of the OECD-Knowledge-based Society first and National Innovation System (NIS) later approaches as its own afforded a major change in the Finland's productive structure. Such strategic decisions were accompanied by the creation of a pool of S&T institutions forming the backbone of a sound public counterpart able of strengthening the public-private interaction needed to face the challenge of a knowledge-driven economy. The Science Policy Council (SPC) created in 1963 put together public and private actors not only to discuss but to define the major targets of the S&T Finnish policy in light of productive and development challenges. Nevertheless, the S&T reforms were not restrained to just an increase on public expenditures or the creation of new public organizations. Education and decentralization were not left behind and important reforms aimed to increase the high skill workers supply and to promote a geographical homogenous development were undertaken. Networks of technical universities and polytechnics were set up in the late 1960s and early 1990s respectively, process which along with the creation of incubators and S&T parks targeted the creation of technological poles throughout the country.

As a result of the new Finnish economy orientation, knowledge-intensive goods production increased at much faster rates than any OECD country; just the share of high-technology exports in total exports rose from 4 percent in the early 1980s to 11 percent in 1990 (Lemola, 2003). It is worth to note that the Finland's economy bases were so sound that even the early 1990s severe economic recession –characterized by a 10 percent decrease in GDP over the 1991-93 period, and unemployment rates of 20 percent- was overcome in a short length due to high export diversification capacity of the economy which had been forged during previous decades.

2.2.2.1 Information and Communication Technologies (ICT) Cluster

An excelling point in Finland's economic development has been the ICT cluster setting up. Such process was the outcome of an upgrading process feasible due to comprehensive investments in human capital and technology. Despite the fact that ICT cluster peaked on the 1990s, the development of the industry is explained on historical factors. In their Finnish ICT cluster review, Blomstrom et al (2002) point to a set of historical conditions. The Finnish telephone network was never monopolized by the state. Finland's national telephone system was established in the late nineteenth century, period during which the country was ruled as a Grand Duchy under Russia. Finnish authorities were worried about increasing Russian influence, so that they decided to grant numerous licenses to private telephone operators as a barrier to a future initiative of Russian nationalization. Once Finland obtained its independence in 1917, a public telephone operator was created, but private operator did not lose their licenses, in light of how difficult would have been to run the highly spread telephone system. Blomstron et al (2002) notes two important effect of the existence of several telephone operators on the development of the Finnish telecommunication market. First, competition brought about technological change. Operators were compelled to improve quality levels constantly, so that new and better products were introduced faster than in other countries. Second, the multi-operator market attracted several international actors such as Ericsson, ITT, and Siemens which set up manufacturing facilities, strengthening competition, and contributing to build new human capital and knowledge ICT capacities.

Three companies have been important for the historical ICT cluster development: *Salora* established in 1929 focusing on radio and television set production; the *State Electric Works* created in 1925 by the Ministry of Defense to produce strategic radio technology, and later on (1970) renamed *Televa*.; and the *Finnish Cable Works* established in 1917 to produce cable, and which later would be one of the cornerstone of Nokia Corporation (Blomstrom and Kokko, 2001). The three firms increased Finnish ICT capabilities by participating in several public and private biddings. Blomstrom et al (2002) identifies the establishment of the Nordic Mobil Telephone (NMT) network as one of the main drivers of the Finnish ICT industry. NMT pushed telecom manufacturers to produce new and highly innovative products in order to meet both the consumer demand and the network product standards once the NMT was in operation in 1980. Several successful joint ventures among local producers were set up aimed to develop new equipments regarding terminals and telecom supporting systems. In addition, in the 1980s Nokia decided to jump into a new market challenge: The Global System for

Mobile Communications (GSM) system. Such path was not easy. High R&D investment rates were needed and Nokia's product structure at the time became an important barrier[13] (Blomstrom et al, 2002). In addition, the early 1990s recession struck significantly Nokia's operation. The number of employees was halved in three years between 1989 and 1992, and the company was put up for sale being just the Rubber and Paper Division sold, since the telecom-electronic division did not find a buyer. Nevertheless, in the middle of such a crisis the company started to reap the benefits of its prior investment on GSM technology development. The breakthrough of GSM technology in 1991, and new marketing strategies allowed Nokia's recovery becoming one of the most important ICT actors worldwide. By the year 2000, Nokia had more than 55,000 employees worldwide and its global market share in the mobile phone market was almost a third. Nokia's stock market value increased from 1 billion dollars in 1990 to 230 billion in 2000, representing 70 percent of the total capitalization at the Helsinki Stock Exchange (Blomstrom et al, 2002). The company accounted for Finland's 70 percent of ICT exports, 45 percent of ICT production, and 30 percent of ICT employment (IMF, 2001). With regard to technological contribution, Nokia R&D expenditures represents approximately 30 percent of national R&D investment, and most of its 21,000 employees are involved in R&D tasks (Blomstrom et al, 2002).

[13] Mobile phones and telephones systems represented just 15 percent of Nokia's turnover. Nokia's preferred high-tech areas at the time were TV sets and information technology, whose market were saturated and generating losses

2.3 Causes of diverging performances

2.3.1 Import Substitution Industrialization (ISI)

After the Great Depression, several countries, fearful of the vulnerability of international markets, decided to look for economic independence by promoting the emergence of industries aimed at local self-sufficiency. Chile and Finland were not the exceptions, closing their economies in an attempt to relinquish their international dependency. However, the end of WWII was the starting point of differing economic strategies. Whereas Chile emphasized an inward process, reducing its international trade activity considerably, Finland, after a short closing period, opened its economy.

In order to ascertain how significant was the impact of ISI in the case of Chile compared to Finland's, I analyze the evolution of two variables: GDP per capita and economy openness. Taking into account the openness performances of both countries I divide the period 1930-99 in three chronological phases: a) 1930-44, involving the post-Great Depression and WWII years, period characterized by the implementation of the first ISI policies in Chile, and the closing of both economies, b) 1945-75, involving the post-WWII years, period characterized by the implementation of trade liberalization policies in Finland and the strengthening of ISI in Chile, and c) 1975-94, period including the implementation of open trade liberalization policies in Chile and the early-1990s-Finland's recession. The openness index performances are presented in Figure 3.

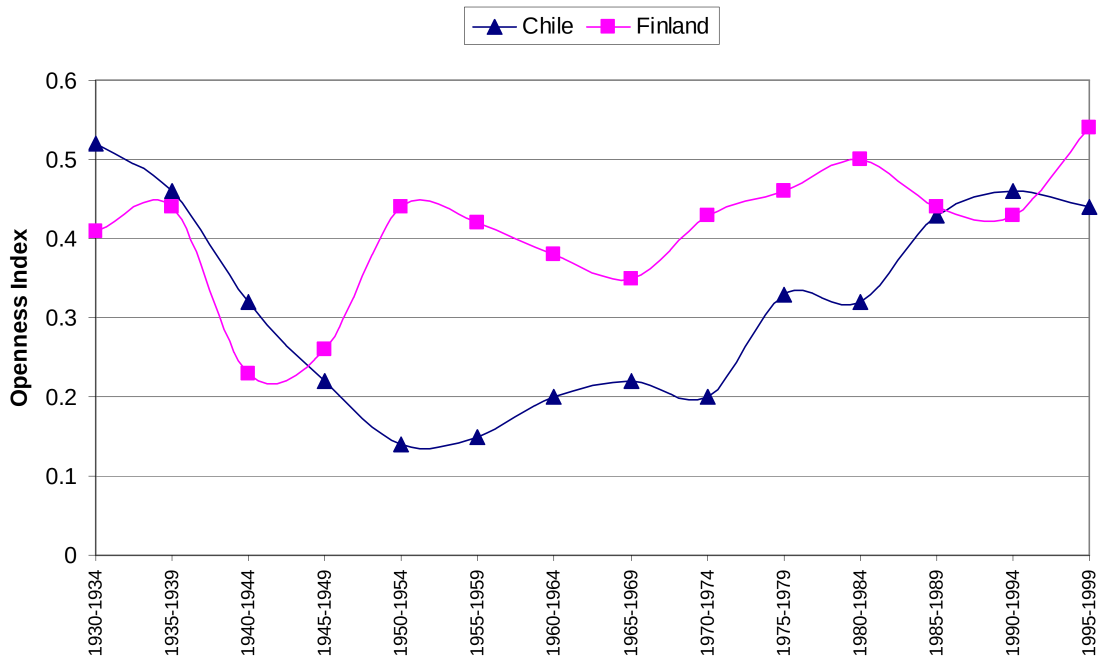

Figure 3: Chile's and Finland's Openness
Source: Maloney (2002)

During the 1930-44 period, openness decreased in both countries, with Chile slightly outperforming Finland. However, Great Depression affected less Finland than Chile as its better GDP per capita performance shows: Finland took a shorter time than Chile to retrieve its pre-Great Depression GDP per capita, as well as its maximum negative change was lower than Chile's[14]. GDP per capita grew at a higher rate in Finland than Chile: 1.57 percent in Finland whereas Chile did at 0.47 percent. During the 1945-75 period, both countries differed significantly in their economic strategies: Chile opt for closing the economy and self-sufficiency whereas Finland implemented several

[14] Chile took 14 years to recover its 1929-GDP per capita (1943), whereas Finland did in 5 years (1934). The maximum negative change in GDP per capita relative to 1929 was 33 percent in the case of Chile and 6.2 percent in the case of Finland.
Author compilation from Maddison (1995)

trade liberalization policies. As a result Chile's openness stayed at lower level whereas Finland's did at higher levels. Such performances were concurrent with their GDP per capita performances: Chile's grew at an average of 0.42 percent, and Finland's did at 3.88 percent. Finally, during the 1975-94 period, Chile sharply increased its openness reaching similar levels than Finland at the early 1990s. Such increase coincided with high growth rates regarding GDP per capita: 2.93 percent in the Chilean case.

Openness and trade has been cited as important determinants of differences in either income or growth (Edwards, 1997). In that sense, ISI protectionism affected the dynamic of Chilean economy by reducing the incentives to innovate and to compete. As basic demands would be covered, asking for either higher levels of quality or new innovative products did not come to mind. ISI stemmed an inefficient industrial sector which did not generate high levels of employment and did not produce enough basic goods to meet consumers' demand (Meller, 1991). Furthermore, the evolution of protectionism led Chile into an excessive bureaucracy regarding trade restrictions putting away entrepreneurship as one of the pillar of the economy, and bringing up having the right connection as the path to higher profits. Finally, ISI did not achieve to modify the productive structure of the economy which was still most concentrated on the production of one commodity: copper whose production was undertaken by local actors but needed a series of intermediate inputs and capital goods which were still imported due to the lack of capacity to produce them at the local level.

2.3.2 Land Reform

There is sound theoretic and empirical support which reinforces the fact that a one-time redistribution of assets can be associated with permanently higher levels of growth (Aghion et al., 1999). Several cross-countries studies have demonstrated that inequality in the distribution of landownership is associated with lower subsequent growth. The cases of Japan, Taiwan, Korea, India, Philippines, South Africa, Brazil and Colombia are good examples of how land reforms have brought about poverty reduction processes characterized by high levels of efficiency (Deininger, 2000).

In the case of Finland, land reform was instituted in the 1920's becoming not only a solution to a specific socio-political problem but also a catalyst to the economy, since the increase in the number of landowners led to an increase in competition, which compelled farmers to introduce techniques that improved their productivity and product quality. The reform empowered small Finnish farmers by granting them ownership and property rights, allowing the creation of a large number of small, medium-sized, privately-owned farms, which led to the more efficient and intensive cultivation of land. According with Haavisto and Kokko (1991) several facts led to confirm the socio-economic return of the Finnish land reform. Firstly, the number of landless rural laborers decreased significantly and tenant farmers disappeared almost entirely in the rural population, replaced by independent farmers. Secondly, the number of farms with more than two hectares of arable land increased from 185,000 to 235,000 between 1920 and 1940. Thirdly, the amount of arable land increased by about one-third during the same period, from 2,015 million hectares in 1920 to 2,631 million hectares in 1940. In order to fulfill this task, Finnish farmers started to explore new mechanics and technology, drawing initially on the talents of local craft-based production and later on the technological innovation of industrialization.

Historically, land ownership was ruled by a “hacienda” system in Chile which stemmed a significant wealth concentration regarding agriculture profits. Such concentration led to lower levels of competitiveness and innovation damaging the agriculture productivity (Ortega, 1987). However, the land reform undertaken since the mid-twentieth century modified the structure of land ownership: the share of farmers owning properties smaller than 20 Basic Irrigated Hectares (BIH) increased from 22.4 percent in 1965 to 46.9 percent in 1976, whereas the share of farmers owning properties larger than 80 BIH decreased from 55.3 percent in 1965 to 24.7 percent in 1976 (see Table 2). However, after taking power, Pinochet instituted a policy to return land to its original owners. Although nearly 35 percent of the land was redistributed (Jarvis, 1985), the new policy did not indicate a complete return to old agrarian structures since the expertise that had been gained through land reform did not disappear. Regarding technological development, Ortega (1987) points out that from 1950 on landowners benefited from several public incentives in order to modernize their methods of production. He highlights the major investments done under the Eduardo Frei’s Administration (1964-1970) aimed to improve the agricultural infrastructure and to promote the creation of agribusiness.

TABLE 2 Distribution of Agricultural Properties by Size in Chile, 1965-1976 (Percent)

	1965	1972	1976
< 5 BIH *	9.7	9.7	9.7
5-20 BIH	12.7	13.0	37.2
20-80 BIH	22.5	38.9	22.3
> 80	55.3	2.9	24.7

Source: Jarvis (1985)
***BIH = Basic irrigated hectare**

The undertaken of Chile's land reform present two main differences regarding Finland's: timing and political environment. Chilean land reform occurred forty years later than Finland's postponing any efficiency gain coming from more size-homogenous distribution of land ownership.. Nevertheless, political situation which led to the land reform in Finland at the early 1920s was quit different than Chile's. Finland's land reform was undertaken under the leadership of the Conservative and Agrarian parties, which represented most of the richest landowners. However, despite its cost to their most important contributors, both parties decided to implement land reform to avert the threat of social revolution at the time, successfully cutting off the source of a long-term conflict that had to be prevented in the future.

In the case of Chile, the land reform implementation was postponed by the lack of political will to undertake it. Most of the traditional parties that ruled Chile during the first half of the century were headed by leaders which electoral bases were strongly related to the Hacienda system whose structure allowed them to drawn on at will of a significant amount of voters, particularly carrying peasants to the voting sites. Even the

Radical Governments of Aguirre Cerda and Rios (1938-46) identified as progressive and social-oriented administrations were reluctant to push a land reform in light of how threatening it could be for their support. Decades later, administrations such as Frei's (1964-70) and Allende's (1970-73) whose welfare bases were not so strongly dependant on the Hacienda system were the ones which implemented it, although at different paces and using different tools. Nevertheless, it is worth to note that the excessive polarization at the early 1970s transformed the implementation of the land reform in a political struggle which diverted it from its original goals, and generated a significant reluctance to accept it from one part of the Chilean society.

2.3.3 Innovation capacity

I use several R&D indicators in order to compare both countries performances. First, regarding S&T expenditures, Chile and Finland have followed increasing trend during the last decades either on absolute or per capita terms (see Figure 4). Nevertheless, their performances differ significantly. Finland total expenditures have been at least nine-fold larger than Chile's for each year of the covered period. One might thinks that such difference might be limited to absolute comparison, therefore taking into account a per capita base might lead to a different conclusion. However, the results are worst. Chile's per capita rate is at least 26-fold smaller than Finland's, with the gap increasing its value during the last years. In 2002, Chile spent 29 dollars per capita in R&D activities whereas Finland did it at 1,447 dollars per capita rate.

The most commonly used indicator fro international comparison purposes is the ratio of on expenditures on R&D to GDP. As Figure 5 shows the difference remains. Finland spent on average 1.98 percent of its GDP on R&D during the 1981-2003 period,

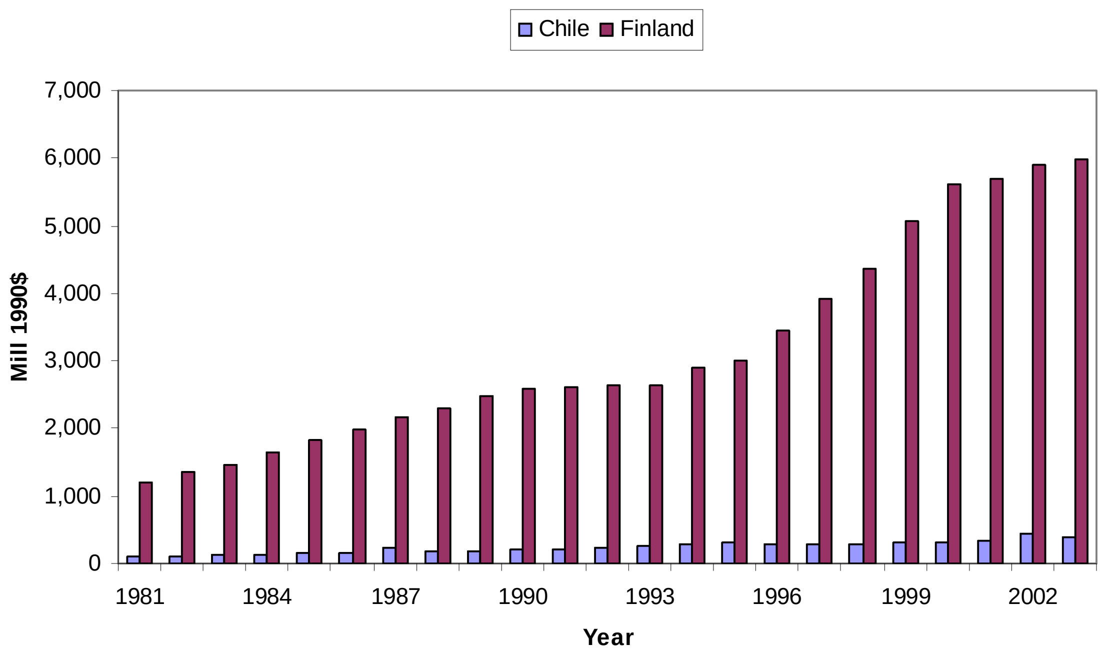

Figure 4: R&D Expenditures 1981-2003
Source: CONICYT

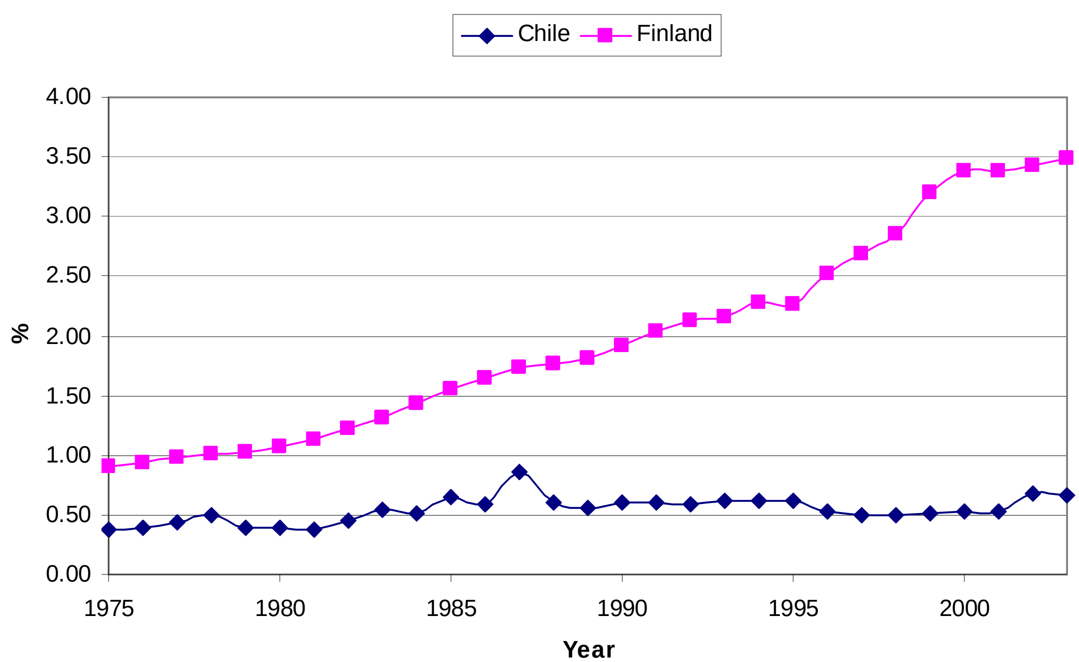

Figure 5: Share of R&D Expenditures in GDP
Source: CONICYT

whereas Chile just 0.55 percent. It is worth to note the increasing gap among both performances since the early 1990s. As long as Finland consolidated its NIS approach adoption, its R&D expenditures significantly increased reaching a 3.48 percent rate in 2003, far from Chile's low 0.67 percent.

With regard to structure of R&D expenditure by funding source, in 2004 53 percent of Chile's R&D is funded by the public sector, whereas 37 percent is allocated by industry. Finland presents a differing performance with 70.8 and 25.5 percent of R&D funded by industry and government respectively (see Figures 6 and 7).

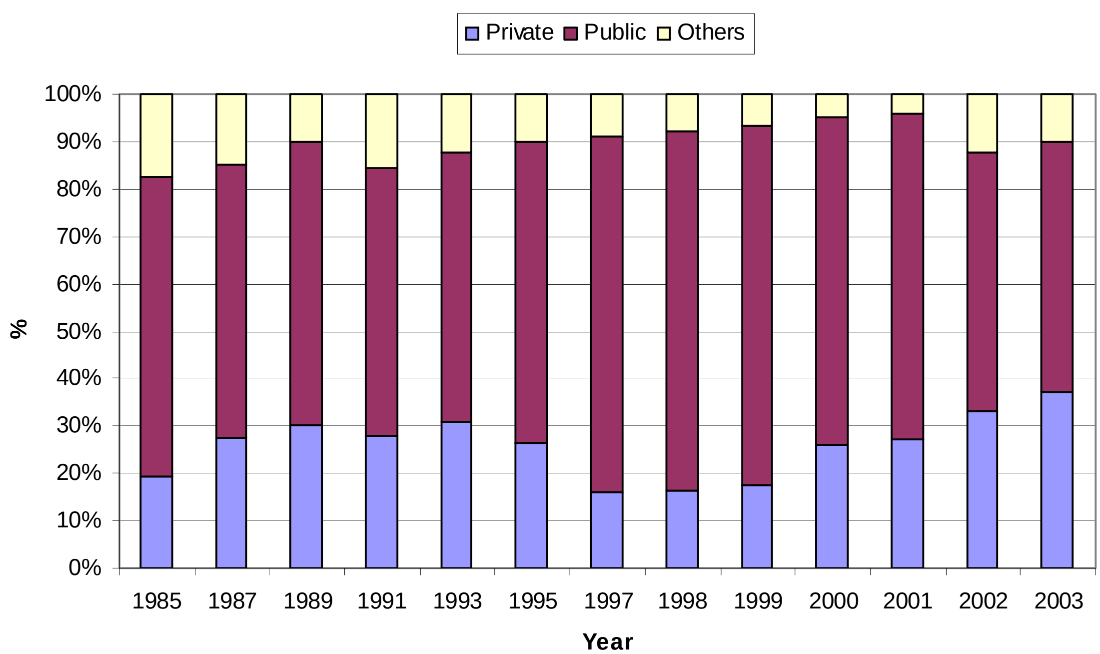

Figure 6: Chile-R&D expenditures by financing sector
Source: CONICYT

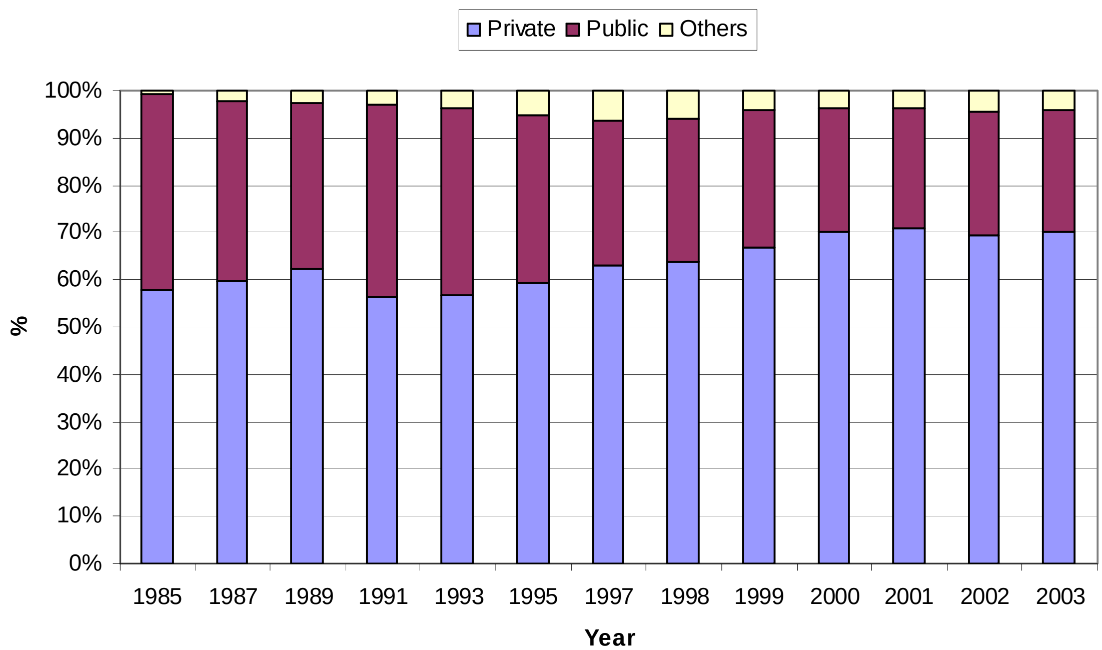

Figure 7: Finland-R&D expenditures by financing sector
Source: EUROSTAT

By continuing analyzing R&D input indicators, the gap existing among both countries not only remains but also expands. With regard to S&T Human Capital, Finland doubled Chile at the early 1980s on number of researchers by having 8,837, whereas Chile had just 3,283. Extending the analysis to per million inhabitant terms, the difference is just expanded with Finland outperforming Chile by more than six times. In the next decades the gap increased reaching in 2001 a significant difference between both performances: whereas Chile reached 498 researchers per million inhabitants, Finland took off by peaking at 7,110 researchers per million inhabitants (see Figure 8).

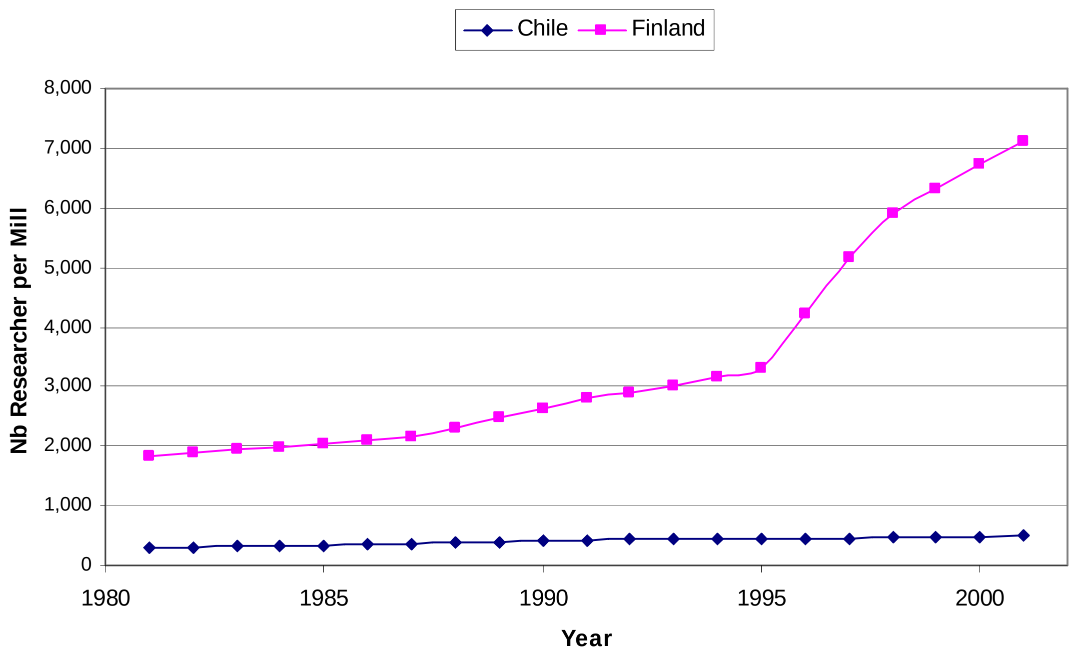

Figure 8: Number of researcher per million inhabitants
Source: RICYT, OECD Main S&T Indicators

With regard to output indicators the Finland-outperforming-Chile trend does not change. Finland's researchers have been significantly most productive in publishing, experiencing a noticeable took off since the early 1990s. The gap among the two countries has done nothing but increasing during the last two decades being Finland publishing productivity ten times larger than Chile's in 2004 (see Figure 9). On the other hand, the performances are much more diverging regarding patent productivity (see Figure 10). Several scholars have pointed Chile's low applied research activity as a proof of its low innovative capacity (CNIC-B, 2006). Finland outperforms Chile, and the gap among both increases throughout the period considered. It is worth to note the stagnant performance of Chile whose patent productivity has not taken off during the last two decades.

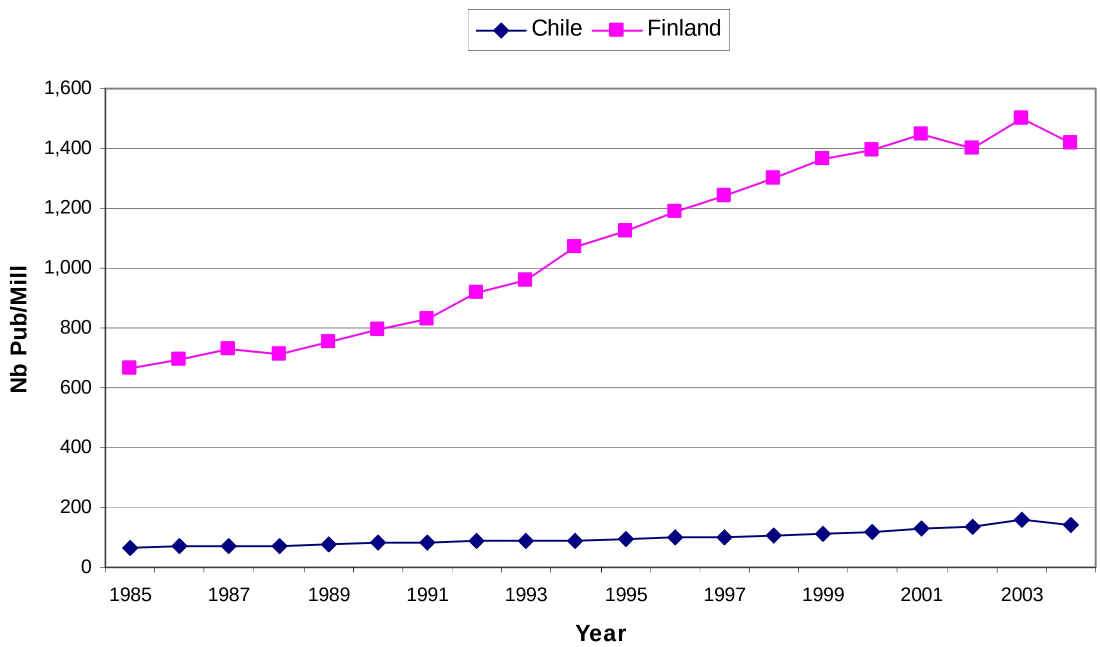

Figure 9: Number of publications per million inhabitants
Source: CONICYT, NSF

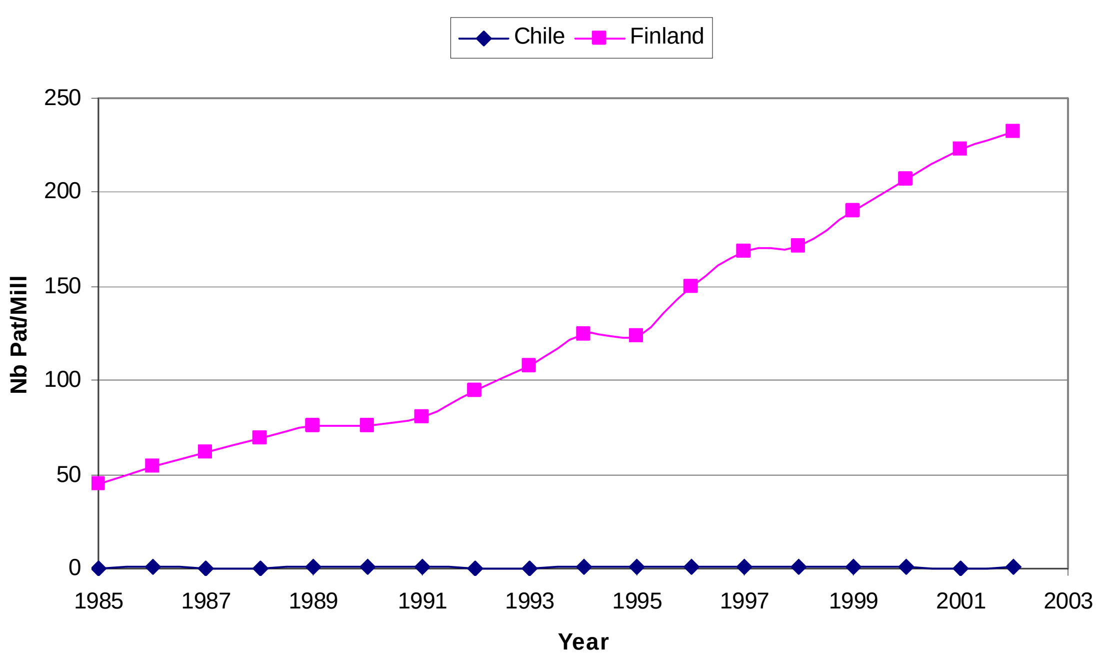

Figure 10: Number of patents per million inhabitants
Source: USPTO

In order to strengthen the innovation-capacity-comparative analysis I present the World Bank Knowledge Assessment Methodology (KAM)[15] indicators, and display a description of each National Innovation System.

2.3.3.1 KAM Index

KAM considers in its analysis four main topics as pillar of the country knowledge performance: economic and institutional regime, education and training, innovation system, and information and communication technology, and provides index values regarding each category. Table 3 presents all the pillars regarding each indicator involved in.

Economic and Institutional Regime is the only area in which Chile's performance overcomes Finland's. It is worth to note that Chile ranks third at the world level (8.96 points) just behind Singapore and Hong Kong. The reasons of the Chilean outstanding performance are based on the quality and probity of its institutions and on its trade liberalization strategy. Finland ranks high on the ranking as well filling the fifth position 8.78 (points).

With regard of the *Education and Training's* pillar there is significant divergence. Whereas Finland leads the rank, Chile ranks at the 46th position. Both countries present high enrollment rates at the primary and secondary level but a significant gap comes up at the tertiary level. Regarding *Innovation System* Finland significantly outperforms Chile.

15 The KAM was designed by the Knowledge for Development Program to proxy a country's preparedness to compete in the knowledge economy using more then 80 structural and qualitative variables. The comparison is undertaken for a group of 128 countries, which includes most of the OECD economies and more than 90 developing countries (see Science, Technology and Innovation topic in World Bank website www.worldbank.org)

TABLE 3 KAM Indicators

Economic and Institutional Regime	CHILE	FINLAND
Tariff and non tariff barriers	1.88 (14)[16]	1.85 (12)
Regulatory Quality		
-Voice and accountability	1.09 (83.0%)[17]	1.50 (98.5%)
-Government effectiveness	1.27 (87.0%)	2.06 (97.6%)
-Regulatory quality	1.62 (94.1%)	1.79 (98.0%)
-Control of corruption	1.44 (88.7%)	2.53 (100%)
Rule of Law	1.16 (85.5%)	1.97 (98.6%)
EIR index	8.96 (3)	8.78 (5)
Education and Training		
Adult literacy rate	95.6%	100%
Primary education enrollment	99.2%	101.7%
Secondary education enrollment	87.8%	127.4%
Tertiary education enrollment	43.2%	86.9%
ET index	6.24 (46)	9.21 (1)
Innovation System		
Expenditures (2002)		
-%GDP in S&T	0.68%	3.46%
-S&T expenditures per capita	26	1,147
-% of S&T expenditures-Public	54.64%	25.5%
-% of S&T expenditures-Private	33.25%	70.8%
Human Resources (2003)		
-Number of researchers	8,658	41,724
-Researcher per million	549	8,003
Productivity (most recent)		
-Scientific journal articles per million	78.11	982.65
-USPTO patent applications per million	1.13	182.76
-University industry collaboration	3.70	6.10
Innovation System Index	5.72(48)	9.73(1)
Information and Communication Technology		
Telephones per 1,000 people	836.10	1,410.30
Computers per 1,000 people	138.70	482.20
Internet users per 10,000 people	2,790.20	6,299.85
ICT Index	6.51(45)	8.71(17)

Source: KAM, World Bank

[16] The number in parenthesis refers the rank of each country
[17] The number in parenthesis refers the percentile rank which indicates the percentage of countries worldwide that rate below the selected country

Whereas Finland ranks first, Chile fills the 48th position. The differences are astonished across input and output indicators. The Finland's share of S&T expenditures in GDP is five times higher than Chile's just as the number of researcher's. It is worth to note the S&T expenditures are mainly funded by the private sector in Finland; quite the contrary is the situation in Chile where the main S&T funding agent is the public sector. Jumping to output indicators the gap widens. The Finnish production of scientific article is ten times higher than Chile's, whereas United States Trademark and Patent Office (USTPO) patent applications registers are one hundred times higher in Finland than Chile. The gap is confirmed regarding the *Information and Communication Technology*'s pillar: Finland occupies the 17th position whereas Chile the 45th.

2.3.3.2 National Innovation Systems

NIS has received several definitions: Freeman (1987) defined NIS as "... the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies"; Lundvall (1992) as "… the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge … and are either located within or rooted inside the borders of a nation state."; Nelson's definition (1993) was "… a set of institutions whose interactions determine the innovative performance … of national firms". However, there are several basic concepts which are common to all NIS definitions: systemic approach, flow of information and learning capacity. In the following sections, I describe Chilean and Finnish NISs.

2.3.3.2.1 Chile NIS

Public, private, academic and social agents such as public agencies and research centers, firms, and universities, are part of Chile’s NIS. In order to describe the Chile’s NIS actors I follow down the National Council of Innovation for Competitiveness (CNIC) Background Report analysis presented to the Organization for Economic Cooperation and Development (OECD) which breaks Chile’s NIS agents in three categories: Public Administration, Innovation Public Funds, and Performers (see Figure 11).

-Public Administration

According to CNIC-A (2006), Chile has not had a formal public institutionality centralizing not only the S&T decisionmaking but the definition of a national strategy setting the orientations of the policymaking process. Chilean S&T goals have been defined through a decentralized pattern pushed by the action of a pool of public agencies such as the National Development Corporation (CORFO) in the Ministry of Economy (MINECOM), the National Commission of Science and Technology (CONICYT) in the Ministry of Education (MINEDUC) and Agrarian Innovation Fund (FIA) in the Ministry of Agriculture, the Ministry of Health (MINSALUD), and the Ministry of Planning and Cooperation (MIDEPLAN) through the Millennium Scientific Initiative (ICM).

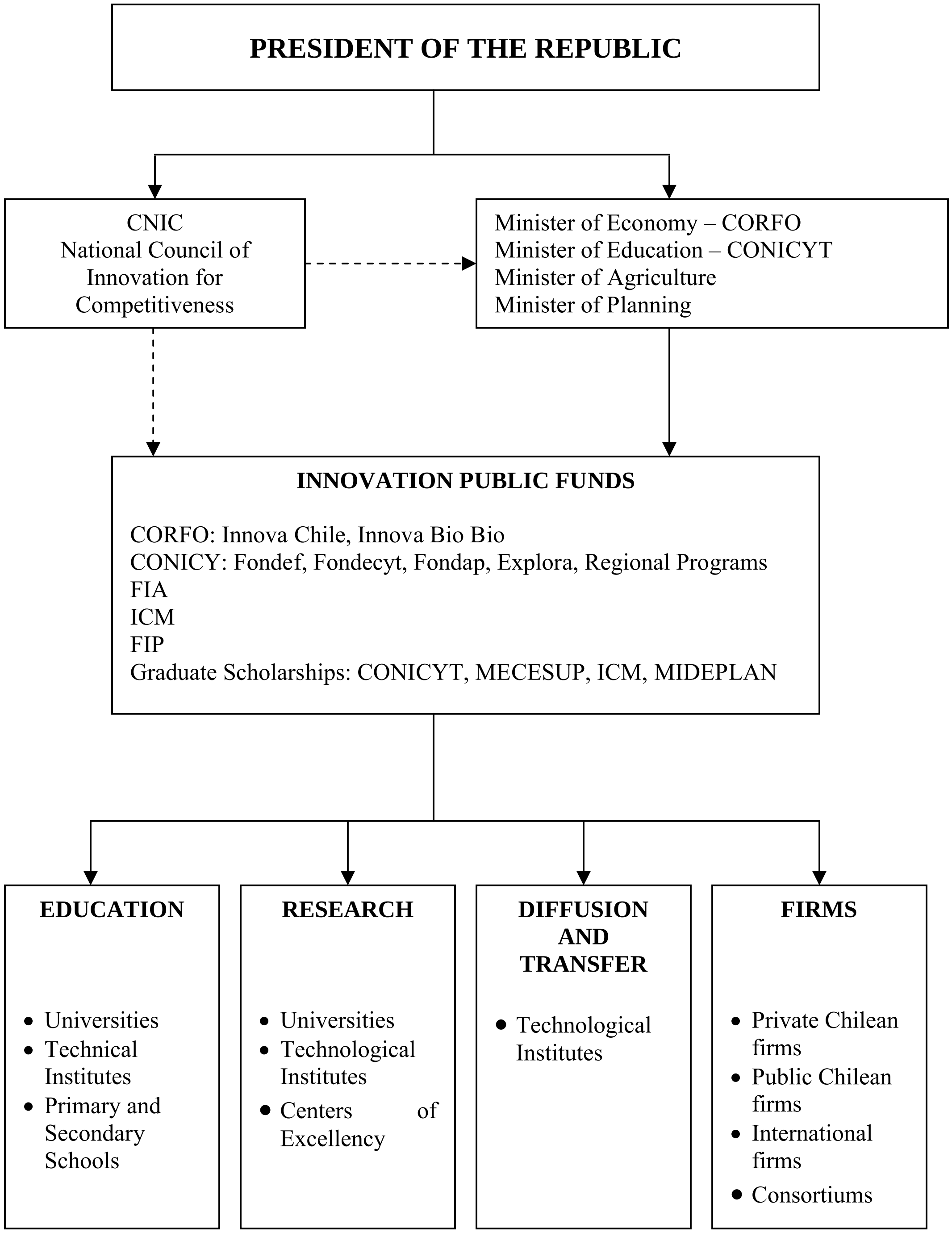

Figure 11 Chile's National Innovation System
Source: CNIC (2006)

In addition, MINECOM and CONICYT have undertaken since the advent of the democratic government (1990) four S&T National Programs: Science and Technology Program (PCT) 1992-1995, Technological Innovation Program 1996-00 (PIT), and Program of Development and Technological Innovation 2001-06 (PDIT), Science and Technology Bicentenary Program (PBCT) 2003-10 launched in 2003 by CONICYT. The four of them have been aimed to achieve an increasing national innovative capacity by setting goals whose definitions have followed a discussion involving actors across society. Nevertheless, the lack of a formal global S&T institutionality is being currently faced the Chilean authorities. In 2005, President Ricardo Lagos sent to Congress a new bill proposing the creation of a new Council, CNIC, and a new technological fund, the National Fund of Innovation and Competitiveness (FNIC). The CNIC creation approval would involve setting a new Presidential Advisory Group aimed to coordinate the pool of organizations participating currently in the Chile's NIS. The CNIC scope would cover issues related with innovation policy including the fields of basic and applied science; technology development, transfer, and diffusion; and human capital. According to CNIC-A (2006), following such path, Chile would achieve the goal of having a sound, conductive, and integral, S&T public administration.

-Innovation Public Funds

The most important agencies in charge of the S&T allocation funds are CONICYT and CORFO. The former created in 1967 is focused on the S&T research promotion and strengthen, on the high skill human resources training, and on the development of new areas of knowledge and of productive innovation; whereas the latter's role is concentrated on the firm's technological areas, transfer and diffusion of technology, precompetitive innovation, entrepreneurship, and high tech investment attraction. Each agency manages its own set of programs aimed to achieve the organization's goals. Among the CONICYT's funds worth to highlight are the National Fund for Scientific and Technological Development (FONDECYT), the Fund for Fostering Scientific and Technological Research (FONDEF), the Fund for Advanced Research in Priority Areas and FONDAP, whereas in CORFO, Innova Chile has a central role. Next, brief descriptions of the funds mentioned so far are presented.

-FONDECYT: Created in 1981 its orientation points towards strengthen basic research across all the knowledge areas. According to CNIC-A (2006), the program has been well evaluated, standing out its excellence, transparency, and discipline coverage.

-FONDEF: Created in 1991, it points to achieve an increasing university-industry partnership. Mainly oriented to university applications, it presents as an essential requirement firms' participation by asking for real economical private contribution in order to ensure that any funded proposal will be addressing an actual industry demand. However, despite the private contribution requirement FONDEF has not been able to arouse the desired industry participation level (CNIC-A, 2006).

-FONDAP: It points to strengthen research groups located at excellence center by funding particularly proposals coming from well-recognized institutions particularly those in possession of high quality scientific doctoral programs. Its goals may be perceived as similar as those of FONDEF, although its main target is the creation of a national critical mass on S&T areas.

-INNOVA CHILE: Recently created, it focuses on the promotion of technological innovation at the firm level through product or process R&D, transfer, adoption absorption, and diffusion of technology. CNIC-A (2006) highlights the good assessment that the program has reached in terms of the firm-support services and tools that it offers.

-FIA: Its mission is promoting the agrarian innovation processes oriented to strengthen the local agricultural innovative activities.

-ICM: Created in 1999 with The World Bank's support, ICM aims to create the so-called Scientific Institutes and Nucleus of Excellence in several disciplines. Nowadays, 3 Institutes and 12 Nucleus are in operation. ICM has been well-evaluated particularly in terms of its international connection and its high respect for excellence.

Regarding the S&T funding, Benavente (2005) points out that the 226 million dollars S&T Chilean public budget may be broken down: 53.1 percent is associated with regular programs such as FONDECYT, FONDEF, and FDI; 16.9 percent is allocated to national technological institutes; 12.8 percent to graduate scholarship either in Chile or abroad; and 10.4 percent is allocated to minor activities. He states that adding the 200 million dollars the State transfer yearly to universities and the 120 million dollars that Industry spends in S&T activities, the whole S&T national budget reaches 500 million dollars representing roughly 0.6 percent of GDP. Table 4 presents a summary of the S&T Chilean programs ordered by public agency.

-Performers

This category includes all those organizations participating in the different phases of the innovation process: universities, research institutes, and productive firms. Within the University System there are several institutions part of the Chilean University Board of Presidents[18] which steadily develop R&D. Among them those worth to highlight are: Universidad de Chile, Pontificia Universidad Catolica de Chile, Universidad de Concepcion, Universidad de Santiago, Universidad Austral de Chile, Universidad de Talca, Universidad Técnica Federico Santa Maria, and Universidad Catolica de Valparaíso. In addition, the public sector has implemented a pool of public technological institutes focused on applied research, development, technology transfer, and drawing and managing natural resources datasets.

[18] The Chilean University Board of Presidents was created in 1954 as an organization in charge of coordinating the national university activity. Currently is formed by 25 universities, six coming from the northern regions, five from the south center regions, five from the southern regions, and nine from the Valparaiso and Metropolitan Region.

TABLE 4 Chile’s S&T Public Programs - National Budget 2004 (M$)

FUND	BUDGET
Ministry of Education	
FONDECYT-CONICYT	40,890
FONDEF-CONICYT	19,038
Graduate National Scholarship-CONICYT	5,882
Explora Program-CONICYT	1,390
Science for the Knowledge Economy Program	9,863
Astronomic Institute Isaac Newton	105
Institutional Development Fund	15,986
Institutional Development Fund-Infrastructure	31,490
Ministry of Economy	
FONTEC-CORFO	14,469
FDI-CORFO	16,244
Bio Bio Technological Innovation Fund (INNOVA BIO BIO)-CORFO	969
Promotion Project Fund (PROFO) and Technological Assistantship Fund (FAT)-CORFO	25,930
Development and Technological Innovation Program	
Development and Technological Innovation Program	3,161
Agriculture Under Secretary (FIA)	1,094
CONICYT	2,707
Fundacion Chile	634
INN	755
Hallmark and Patent Program	501
Fishery Research Fund (FIP)	4,251
Fishery Promotion Institute	753
Fundacion Chile	1,371
Ministry of Agriculture	
Agrarian Innovation Foundation (FIA)	6,665
National Institute of Agrarian Innovation (INIA)	13,820
Forestry Institute (INFOR)	1,776
Natural Resources Information Center (CIREN)	803
Fundacion Chile	1,721
Ministry of Planning and Cooperation	
Millenium Scientific Initiative	6,942
Graduate Scholarship Program	9,961
Ministry of Mining	
Nuclear Energy Chilean Commission	7,651
Geology and Mining National Service (SERNEAGEOMIN)	7,807
Ministry of Defense	
Hydrographic and Oceanographic Service-NAVY	4,928
Military Geographic Institute	2,119
Aerophotogrammetric Service-AIR FORCE	782
Ministry of Foreign Affairs	
Antarctic Chilean Institute	3,703
TOTAL	**266,161**

Source: Eyzaguirre, 2005

Institutions such as Natural Resources Research Center, Fishing Promotion Institute, National Institute of Standardization, National Institute of Forest Research, National Institute of Agrarian Research, National Service of Geology and Mining, Mining and Metallurgy Research Center, and the Fundacion Chile are good examples of such path. The industry has a low participation on either funding or undertaking R&D activity-just 33.25 percent of the R&D is private-funded. According to CNIC-A (2006), such situation is explained in light of the lack of innovation-related aspects on the firms' strategy. Most of these firms are part of the economic sectors presenting comparative advantages in terms of the national characteristics, and are ranked as large firms in light of their size sales.

-Interactions among Chile's NIS actors

Several scholars have presented assessment reports regarding Chile's NIS (CNIC-A, 2006, OECD, 2005; OECD, 2005; Holm-Nielsen and Agapitova, 2002). With regard to the Chile's NIS actors interactions it is feasible to come across with some common critical patterns. First, a duplication problem is noted. As S&T agencies do not follow a common strategy or are not headed by a central authority, some of their targets may be overlapping others agencies' leading to duplicating funding occurrence. Such lack has damaged pursuing more efficient, coherent, and effective public action in terms of the coordination and linkage of public S&T agencies. Second, a common critic is the weakness of the linkages within Chile's NIS. At the industry level, OECD (2005) cites the low interaction among the agents involved in the clusters' productive chains as a serious constraint to achieve an increasing innovative capacity. Such performance may be due to the mistrust existing among the productive actors leading to higher transaction costs putting up the price of innovation. The weak-linkage critic is extended to the public research institutes. CNIC-B (2006) notes that usually isolating work is a common characteristic of public research institutes achieving low collaboration rates either at the national or the international level, deterring them from fruitful participation on S&T networks. Nevertheless, the university-industry link is focus of major critics in light of its weakness and low exploitation. The causes behind such feeble link may be on the university's lack of a practical and productive vision with regard to research goals definition which might lead to develop non-commercially-exploited innovations due to their high adaptable or transferable costs. On the other hand, timing and return are still a sizeable constraint for increasing innovation rate at the industry level. Most of the firms do not conceive yet that innovation may need longer time periods not only to produce investment returns but to achieve technical results. Therefore, innovation is still perceived by industry as an expensive and long-term-answering activity. Third, with regard to educational and training activities, scholars contrast a positive input such as the proliferation of graduate programs, particularly at the doctoral level, with their low graduating rates, identifying it as a prove of how badly teaching and technical resources are managed at the tertiary level (CNIC-A, 2006). They add the low associativity rate among national and with international universities as an issue to be corrected in light of improving the current quality of local doctoral programs. In addition, S&E education, namely tertiary level and Vocational Education Training (VET), has been targeted as no-matching the industry demand. According to CNIC-A (2006), career supply might not been covering the actual worker-skill industry needs as a whole, in light of the low number of degrees offered focused on innovation process relevant areas such as biotech and ICTs.

-S&T Public Policies

With regard to S&T Public Policy Implementation, it is worth to highlight that most of the S&T Chile's activity started out with the CONICYT creation in 1967 under the Eduardo Frei's Administration. CONICYT has been portrayed as an important pillar of the S&T-activity funding, recognizing it as a professional, committed and transparent organization (CIID, 1998). Later on, in 1981, FONDECYT was launched aimed to promote basic research among the S&T national community, particularly at the academia level. In the early 1990s, with the advent of the democratic governments, several S&T reforms took place. The first one of them was the implementation of the Science and Technology Program 1992-95 (PCT), a national plan funded by the Inter-American Development Bank. The main PCT goal was to promote technological innovation at the firm level and to strengthen R&D activities. Two new funds were created: the National Fund for Technological and Productive Development (FONTEC) and FONDEF, the former under CORFO's administration and the latter under CONICYT's. FONTEC focused on co-funding technological innovation initiatives at the firm level, whereas FONDEF, R&D concentrated on projects proposed by universities associated with firms. In addition, FONDECYT was incorporated to the program, and its budget increased. PCT was the highest S&T public investment at the time, and in addition to contribute to increase Chile's innovative activity it modified the allocation process by shifting the old direct-decision pattern by one based on proposal's competition, affording higher transparency and efficiency levels. Once PCT period ended, Chilean authorities decided to launch a second S&T national plan: Technological Innovation Program 1996-00 (PIT). PIT differed from its antecessor in its stronger emphasis on promoting innovation at the firm level, decreasing the basic research support in terms of what PCT did. The major PIT accomplishments were to position innovation among the industry community as a necessary and feasible practice, to contribute to develop new emerging economical sectors, and to identify strategic new technological areas (CNIC-A, 2006). Later on, and Program of Development and Technological Innovation (PDIT) 2001-06 was launched. PDIT's mission was to accomplish a competitiveness increase by means of supporting innovation and technological development in Chile's economy strategic areas, particularly at the SME level. Such aim was stated in light of an early S&T activity diagnosis suggesting that despite the successful implementation of the S&T programs during the 1990s there were some economical sector innovation-demands that had not been addressed (CNIC-A, 2006). The causes behind that would have been the autonomy of the market and the "horizontal-type" innovative funds. Thereby, authorities decided to implement a strategy based on strengthening some specific "platform" S&T disciplines: biotechnology and ICTs. Lately, the Science and Technology Bicentenary Program (PBCT) 2003-10 was created aiming to support and to head the process leading Chile into the Knowledge Economy by means of investing in S&T and innovation activities addressing the industry demands[19]. The program has promoted an active university-industry interaction through the implementation of several technological consortium most

[19] http://www.conicyt.cl/bancomundial/

of them focusing on adding value to natural resources sectors activity. In spite of the accomplishment of each program's goals, Chile still not has a formal S&T institutionality able to propose and to implement a national S&T strategy. The NIS is composed of a pool of S&T-oriented institutions spread throughout the public sector. Facing that challenge, Chilean authorities are working on a three steps new strategy. First, the National Council of Innovation for Competitiveness (CNIC) creation has been proposed targeting the integration of all S&T agents, coming from the public, private, and academia sectors, under one common umbrella. CNIC will be in charge of designing the S&T national policy by means of a process involving all the actors participating currently on it. Second, as part of its tasks, CNIC will be responsible of proposing a new S&T national strategy which will have to include topics ranging from research areas, human capital, and the development, transfer and diffusion of technology. Finally, the National Fund of Innovation and Competitiveness (FNIC) will be launched using the implementation of a new tax mining whose revenues will be allocated to it. FNIC will point to funding innovation initiatives aimed to increase national competitiveness consistently with the S&T Strategy goals.

2.3.3.2.2 Finland NIS

In order to offer a thorough description of the Finnish NIS, I present a two-section analysis. The first one looks upon the role of NIS actors, focusing on agents involved in designing, coordinating, and performing activities. The second one regards description of a set of outstanding features of the Finnish NIS, key on the accomplishment of Finland's jump into the knowledge economy. In Figure 12 I present a Finland's NIS scheme.

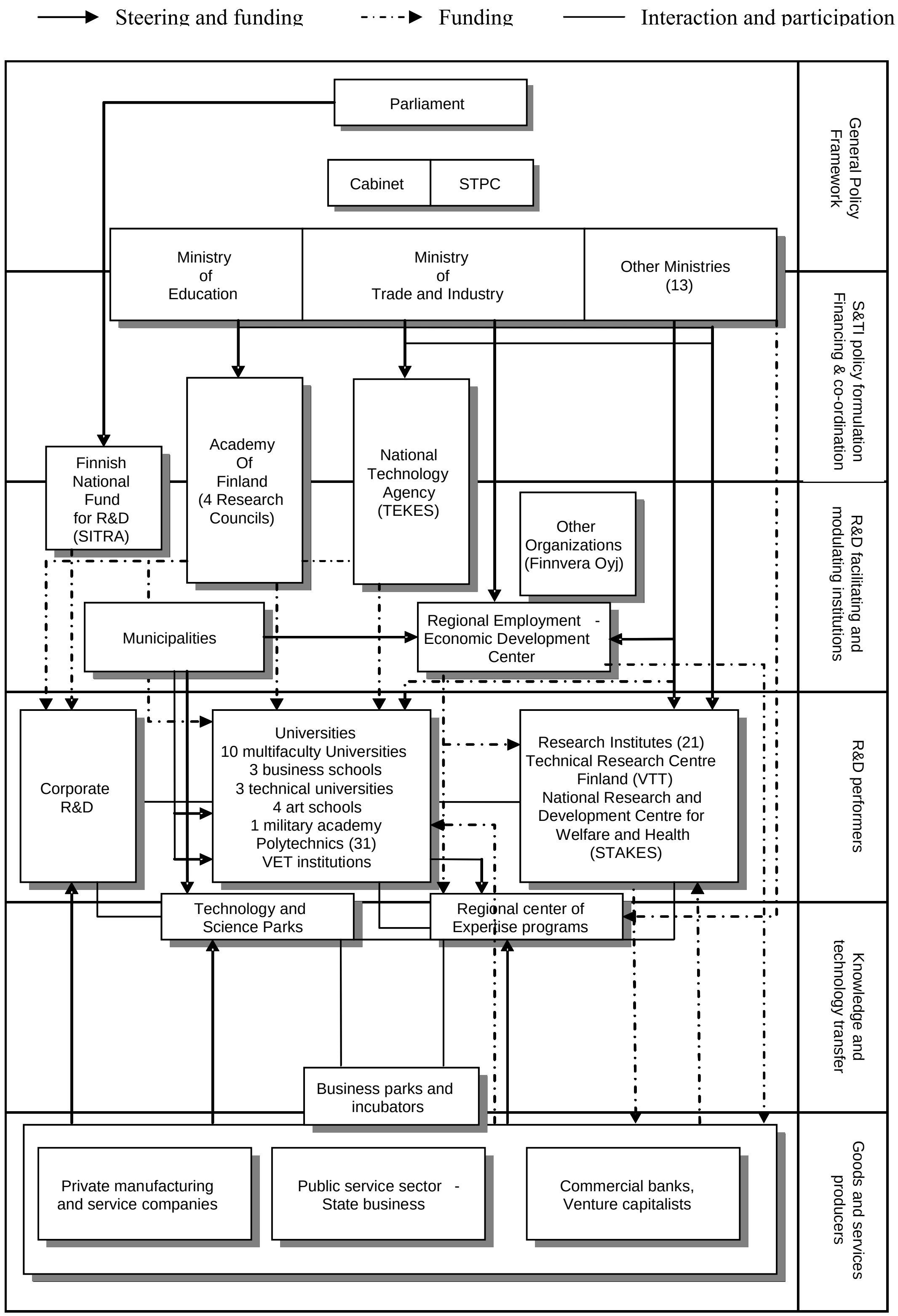

Figure 12 Finnish National Innovation System
Source: Nieminen and Kaukonen, SITRA 2001

-Finland's NIS Public Actors

With regard to policy making bodies those playing the highest roles are the Parliament, the Cabinet, and particularly the Science and Technology Policy Council of Finland (STPC). STPC is responsible for the strategic development and coordination of Finnish S&T policy as well as of the national innovation system as a whole. Chaired by the Prime Minister, its memberships consists of the Minister of Education (MINEDU), the Minister of Trade and Industry (MTI), the Minister of Finance, and 0-4 other ministers appointed by the Council of State. In addition, ten highest-level representatives of academia, industry (Nokia's CEO at present), the Academy of Finland, the National Technology Agency (TEKES), and employers and employee organizations. Thereby, STPC is nowadays a platform of discussion where public, private and academic agents define the main aims of the innovation national strategy. In order to achieve such task, STPC provides a triennial report identifying the main innovation challenges faced by Finland along with a set of policy guidelines to overcome them. Published in 2006, "Science, Technology and Innovation" is the latest one. It recommends keeping strengthening the innovative capability of the Finnish economy, and states as the major targets of the Finnish S&T strategy: 1) promote the overall functionality of the innovation system and the system's ability to renew itself, 2) enhance the knowledge base, 3) improve the quality and targeting of research, 4) promote the adaptation and commercialization of research results, and 5) secure adequate economic prerequisites for the activities (STPC, 2006). It is worth to note the social scope of the STPC's proposal showed on the following statement:

"…education, science, technology, and innovation policies of the coming years may be judged successful if they contribute to the development of the **whole society** and the innovation system in the intended manner…" (STPC, 2006, p.2)

MINEDU and MTI are the two most important ministries within Finland's NIS. Together both ministries oversee nearly 80 percent of the R&D public budget (ERRIN, 2005). MINEDU manages 21 universities and 31 polytechnics aiming to address both the high skill worker and the knowledge market demands. Nevertheless, the main MINEDU task has to do with the administration of The Academy of Finland. Founded in its present form in 1970, the Academy aimed to fund basic research and to support academic careers by means of individual projects competition and academic posts and training. Nowadays, The Academy groups its task on four councils, Biosciences and Environment, Culture and Society, Natural Sciences, and Engineering and Health. The broad scope of The Academy's working areas has afforded a strong funding competition among Finnish researchers. Applicants have notably increased, receiving The Academy three times more applications than it is able to fund (ERRIN, 2005). One of the most important achievements of The Academy has been the establishment since 1993 of the Centres of Excellence, research group aimed to develop cutting edge research whose selection has been made following an open competition process based on high quality standards.

MTI is more focused on promoting S&T at the industry level, handling technological policies, and administrating TEKES. Established in 1983, TEKES has played a significant role in funding technological development in Finland by channeling nearly 30 percent of the public research budget (ERRIN, 2005). TEKES funds mostly proposals coming from industry, particularly those presenting a high level of risk. In addition, it look forwards networking and internationalization, and often is not the only financer of the approved proposals. Proposals involving high levels of networking were strongly rewarded by TEKES. Castells and Himanen (2001) point out that the more networking there is between large companies, between large and small and medium companies, or between SMEs, the larger the TEKES funding share, rising from 50 to 70 percent. In addition Castells and Himanen stress three features: 1) TEKES efficiency in funding R&D aiming at exportable products, emphasizing its involvement in all successful Finnish technology companies at some point in their development, including Nokia; 2) TEKES administration autonomy, despite the agency is responsible to MTI, the latter is not involved in funding decision, affording it to act with a much longer perspective than if it were within political structure; and 3) TEKES acts proactively and reactively, the agency has been able to define its own working areas through steering committees implementation in which industry actors have had an important participation; notwithstanding, TEKES is not closed to new research areas that may not be part of its own technological programs but may be included in new individual proposals.

Closing the main chain of S&T funding-agencies is the Finnish Fund for Research and Development (SITRA). Created in 1967, SITRA provides venture capital and support firms exploring new innovative field areas and conducting experimental research. The agency is nowadays a venture capitalist institution funding the seed and expansion steps of start-up companies whose development phase has been already financed by TEKES. Therefore, both agencies work very close. In fact, 95 percent of the SITRA-funded proposals have already received money from TEKES. In addition, SITRA reinforces its explorative profile promoting technology diffusion and foresight by means of funding technological seminars and conducting innovation policy assessment studies. Castells and Himanen (2001) define SITRA's role as to be a "public capitalist" and an "unofficial strategist".

-Performers

The main Finnish research performers are universities, polytechnics, research institutes and firms. Universities perform world-class research in several fields, standing out the high tech work of the technical universities in Helsinki, Tampere and Lappeenranta. The excelling university performance is reinforced by the industrial research development, which accounts for 68 percent of the national S&T expenditures[20]. Nokia have played a fundamental role on achieving an increasing private R&D funding. Nokia has experienced an explosive growth period as an outcome of its technology-oriented market strategy increasing its stock market value from around 1 billion dollars in 1990 to 230 billion dollars in 2000, representing 70 percent of the total capitalization at the Helsinki Stock Exchange (Blomstrom et al, 2002). Nowadays, Nokia's global market share in mobile phones is nearly on third, and the company accounted for 70-80 percent of Finland's ICT exports, 45 percent of ICT production, and 30 percent of ICT employment (IMF, 2001). Blomstron et al (2001) point out that about a third of Nokia's worldwide employees work in R&D, and that company's R&D expenditures represent 30 percent of Finland's R&D investment. In addition of universities and firms, twenty public

[20] http://www.stat.fi

research institutes such as the Technical Research Center (VTT), the National Public Health Institute, the Institute of Occupational Health, the Forest Research Institute and the Agri-food Research Finland conduct R&D. With regards to VTT, defined as the largest research institute in the Nordic Countries, it carries out mainly applied research, hired by private contractors, affording it a significant level of autonomy. VTT employs roughly 2,720 researchers and provide R&D for over 6,000 domestic and international customers[21].

One of the main boosters of Finnish innovation has been the spread of intermediary institutions across the country. This category includes science and technology parks, technology transfer companies, industrial liaison offices and innovation centers as well. Their roles range from offering innovative business environment and infrastructure, being home of several industrial companies in the case of S&T parks, to promoting the commercialization of research results from universities and research institutes. Such technology transfer companies help costumers in assessing new research results, patenting, licensing, business development, and marketing. Regarding the S&T parks operation, it is worth to highlight the existence of the Finnish Science Park Association (TEKEL). Founded in 1988, TEKEL has nowadays 23 members, involving 2 400 enterprises, 50 000 experts working on different technology fields such as ICT, healthcare and medical technology, biotechnology, environmental and food technology, materials research and digital media[22].

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[21] VTT in figures, http://www.vtt.fi/vtt/vtt_in_figures.jsp
[22] TEKEL, http://www.tekel.fi/english/

-The Finnish Education System

Dahlman et al (2005) identify education as the key element of a knowledge-based, innovation-driven economy, since human capital complements technological change. They point out that an insufficiently trained worked force may be a serious barrier to achieve the new technologies in production. Finland has not been the rule exception. Its educational system is soundly built upon of model consisting of basic education, post-comprehensive school, higher and adult education(see Figure 13) with each level ranked among the best worldwide (OECD, 2000). Finnish public education spending accounts for 13 percent of all public expenditure, with two third of it coming from State funding and the third left from Municipal funding.

The current shape of the Finland educational system has been the outcome of a steady upgrade process started at mid-twentieth century driven by an increasing social demand for academically educated labor. At the beginning of the century just three universities located in the urbanized areas of Helsinki and Turku formed the tertiary Finnish educational system. In the late 1960s, Finland carried out a significant university reform aimed to set a geographical homogenously training capacity throughout the country. Therefore the reduced network existing at the time was expanded to Eastern and Northern

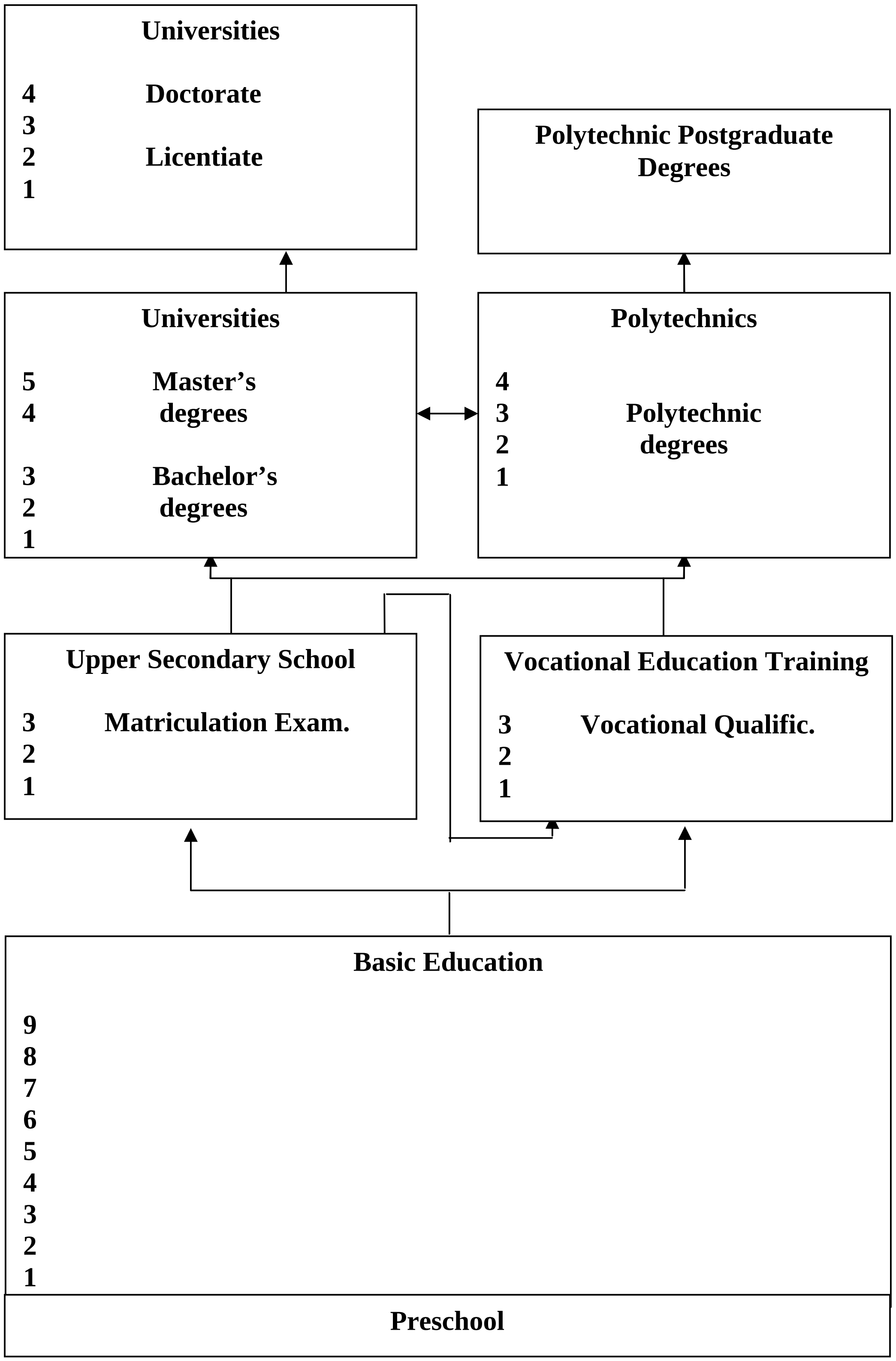

Figure 13 The Education System in Finland
Source: MINEDU (2004)

Finland by establishing universities in the Oulu, Joensuu, Lappeenranta and, Kuopio Regions.

The number of students increases at a 20-30,000 rate per decade between 1960 and 1990, whereas in light of the strengthening of the ICT cluster during the 1990s, such rate rose to 45,000 students per year (ERRIN, 2005). Nowadays, there are 21 universities in Finland specialized in fields such as technology, engineering, economics and business management, or art. Nevertheless all of them present a common characteristic: the basic goal of performing R&D providing a tertiary training in connection with it. In the early 1990s, a polytechnic reform took place aimed to address the increasing demand for specialized technological training driven in part by the ICTs blossoming. A network of 31 polytechnics was gradually implemented by means of a merging process of different vocational educational schools upgrading their education level to meet the standards of higher education. The number of polytechnic students has risen twentyfold since the early 1990s (Kekkonen, 2005). The success of the higher education improvement process has afforded meeting the high skill worker industry demand, granting that more than 30 percent of Finland's population have a higher education degree.

Finland's nine years is offered in comprehensive schools and it is an obligation for every Finnish citizen to complete it. Post-comprehensive school education is given by upper secondary schools and vocational schools, the former covers all the country and lasts three year at the end of which students take the national matriculation exam. Finnish vocational schools Finnish vocational education is traditionally institution-based to a large extent (MINEDU, 2004). A mix of taught courses and on-the-job training is included in the study program. With regard to adult education, worth to note is that is offered at about 1,000 institutions throughout the country, with more than 1 million people participating on it (MINEDU, 2004).

-University-Industry Relationship

Finland's NIS has been identifying as an international benchmark regarding university-industry cooperation. In 2003, most of large company R&D projects and 80 percent of SMEs R&D projects involve university participation (ERRIN, 2005). Such cooperating relationship has strongly stimulated knowledge creation, technology transfer, and an increasing social capital. Nevertheless, such achievement has been the outcome of a long and steady upgrading process. In the 1970s, cooperation with industry was not promoted among universities whose role was mainly associated with their educational goal postponing research activities. Along the 1980s and 1990s the trend shifted by establishing a set of public policies focusing on addressing the industry R&D demand. As the NIS approach was adopted as the economic development strategy, economic effectiveness of research was given higher priority. The R&D funding mechanism was modified not only by increasing significantly the university-research budget but also by defining research cooperation with industry as the most important factor on the allocation-decision. In addition, the severe recession experienced by Finland at the early 1990s had a "collateral" effect on university-industry research. As the recession went on, a set of cutbacks affected the R&D funding system, therefore Finnish universities experienced severe decreases on their research budgets being compelled to look for new R&D funding sources, since public allocations were mostly channeled to education expenditures. Thus, external R&D funding sources represented a fruitful solution not only for universities but also for industry whose R&D demand became the main driver of new R&D university proposals. Following such trend, the amount of external research funding in the higher education was at the end of 2002 at 57 percent of which 13 percent came from foreign companies (ERRIN, 2005).

-Venture Capital

The growth of the Finnish venture capital market and the innovation-driven-economy-strategy promotion have been two complementary phenomenons by mutually strengthening each other. Since the early 1980s, SITRA began to create a set of venture capital funds not previously available in Finland. The venture capital market experienced a rapid evolution (see Table 5). In 1988, just 18 venture capital companies were in operation managing a total capital of 100 million euros, whereas in the upper 1990s, particularly driven by the ICT boom, the number of venture capital companies had tripled and their budgets were about 300 million euros (ERRIN, 2005). Nowadays, more than 50 venture capital companies are operating in Finland managing 3.2 billion euros. According to ERRIN (2005), in 2002 these companies made a total of 462 investments amounting to 391 million euros.

TABLE 5 Finland's Venture Capital Investments 1995-2000

Year	Number of cases	Growth (%)	Investment (mill of euros)	Growth (%)
1995	122	6	37.8	34
1996	137	12	83.8	122
1997	205	50	136.4	63
1998	265	29	192.4	41
1999	350	32	285.4	48
2000	420	20	403.7	41

Source: IMF (2001)

-Regional Innovation Systems

Finland has been able of building a set of regional innovation systems over R&D activities. Such regional rise has been the outcome of several R&D, politic, and economical measures. With regard to R&D capacity building, Finland launched in the late 1960s a technological university network which has afforded a steady and homogenous high-skill workers supply along the country. The effect of such initiative was strengthened in the early 1990s with the implementation of the polytechnic network affording higher rates of science and engineering graduates. The enactment of the Regional Development Act in 1994 was a major driver of the Finnish decentralization process. The Act aimed to increase the role of local government in regional policy by delegating power from the central to the regional level. Such power delegation was strengthened by launching two important economic development organizations at the regional level: The Employment and Economic Development Center (EEDC) and the Center of Expertise Program (CEP). EEDCs support SMEs, promote technological development in firms, and assist in matters concerning export, patent, and internationalization activities. CEPs aim to increase local R&D capacities by building regional centers of innovation in various technology fields related to regional strengths. Both institutions involved the participation of different participations. The former includes representatives of the Ministry of Trade and Industry, the Ministry of Labor, and the Ministry of Forestry and Agriculture, whereas the latter are implemented over the cooperation between industry, local governments, technology centers, universities, polytechnics, and research institutes.

CHAPTER 3

MODEL, RESULTS AND ANALYSIS

In this section I present a brief literature review regarding the impact and contribution of technological change in economic growth in order to introduce the analytical model used to achieve the research goals. Next, I present the model and its results followed by the analysis of them which is concentrated on the main factors behind the S&T gap among the two countries.

3.1 Literature review

The challenge of modeling economic growth has followed a long path. Solow (1956, 1957) identifies growth performance as the result of the accumulation of factors, namely capital and labor, predicting declining rates for nations with high capital labor ratios. Assuming diminishing marginal productivity of capital, constant saving and population growth rates, Solow predicts that all countries *converge* in the long-run to the same level of income. In addition he assumes that the technological progress is exogenous and does not respond to incentives. It is worth to note that the technology exogenous Solow's definition remained as a key part of economic growth modeling during an extensive period, despite some notable challenges such as Arrow's (1962) model of learning by doing, and Uzawa's (1965) model of human-capital driven improvements.

Later on several facts led to question the exogenous feature assigned to technology by Solow. Helpman (2004) cites as one of Solow's limitation the persistence of high growth rates in richest countries over time, even improving their performance in some cases. Despite the world growth, convergence has not been a common situation. As a result of such discussion, the endogenous growth theory emerged with Romer (1986) and Lucas (1988) as its main precursors. Romer argues that growth not only depend on labor and capital, but also on an economy's stock knowledge which rises as firms invest in knowledge accumulation. At the same time, he points out that firms' output not only depend on their own private stock of knowledge but on the aggregate economy's stock of knowledge. Knowledge accumulation generates externalities which allow increasing return to scale which offset the decreasing return to scale from factor accumulation. Lucas (1988) introduces the use of externalities but associated to human capital. He states that the decreasing marginal return of capital can be offset as long as the average level of human capital in the economy is high, leading to growth rates higher than technological progress. Later on, several studies have analyzed the role of education and human capital in economic growth such as: Goldin and Katz (2001) regarding the case of the US, and Young (1995), regarding Asian countries.

Romer (1990) expands the endogenous growth theory disaggregating his own model. Regarding copyrights, Romer points out that innovators have incentives to innovate, and at the same time, innovators create knowledge beyond copyright limits which can be used by everybody (spillovers). He states that at the nation level the higher the R&D investment the higher the productivity growth which is endogenous since it depends on the economy's characteristics especially those which determine the saving rate. Grossman and Helpman (1991) and Aghion and Howitt (1992) present alternative interpretations where products are not equally substitutable, going against Romer's assumption, and improve along quality ladders. They state that improvement over time increases growth performance.

The Solow's convergence theory has been retaken by several scholars. Following the rational that countries differ in their population growth and saving rates and basing their work on Solow's premises, Barro and Sala-i-Martin (1992) and Mankiw et al (1992) state that rich countries and poor countries converge to different income levels. On the other hand, Klenow and Rodriguez-Clare (1997) note that ignoring the complementarity between technological progress and capital accumulation leads to underestimating the role of technology in development. Acemoglu and Zilliboti (2001) reinforce the role of interaction between human capital and technological progress as growth catalysts. Easterly and Levine (2001) points out that long-term development is mainly driven by the portion of growth that is unrelated to capital accumulation. Mainly, as Lederman and Saenz (2005, p.2) states "growth seems to depend crucially on factors that determine the rate of technological progress that might be country specific as opposed to common to all countries".

Helpman (2004) points out that more than half of the cross-country variation in income per capita comes from differences in Total Factor Productivity (TFP) levels whose fluctuations are mainly due to diverging R&D investment rates. On one hand, innovating-countries benefit from its own R&D and from other countries's R&D, whereas less developed countries benefit mainly from innovating-countries R&D activities since their low R&D investment rates prevents them from having a strong local R&D capacity. Following such rational Helpman argues that the world technology frontier is pushed forward by an all-countries effort, and this influences in a differential manner the growth of countries at different development stages, and thereby their TFP speed growth. Industrialized countries have to innovate to move the technological frontier forward, whereas LDCs are just in the middle of a catching up process; therefore, returns to R&D investment vary according to the level of development, the richer the country, the smaller returns to R&D.

3.2 The Model

I test two hypotheses:

Hypothesis 1: Chile's R&D contribution to national income per capita has been higher than Finland's over the period 1981-2000.

Hypothesis 2: NRA has been a better complement of R&D in the case of Chile than Finland over the period 1981-2000.

I define the model on prior empirical work regarding economic growth which has followed research based on Solow's model. I define as the dependent variable the log of GDP per capita over the 1981-2000 period. The analysis includes as independent variables investment as a fraction of GDP (I); labor growth measured as yearly growth rate of the economic active population (L); the share of R&D expenditures in GDP (RD); and the share of natural resources exports in total exports (NR)[23]. With regard to RD, lags

[23] As natural resources endowment is measured in value terms it captures not only supply effects but also impact on current account and/or in exchange rate of higher prices of some commodities

of several kinds are likely to be occurred between R&D expenditures and economic growth (Rouvinen, 2002). Goal and Ram (1994) cite three of them as the most significant. Firstly, there is a lag between R&D spent and completion of projects. Secondly, there may be a lag between project completion and the increase on productivity which may lead to economic growth. Thirdly, there is bell-shaped pattern in the time path of increase in productivity. Defining the lag value to be used, the US Bureau of Labor Statistics proposes using a 2-years-lag for applied research and 5-years-lag for basic research; however, its analysis is just focused on US Industry, not including plausible country endogenous features. CNIC-B (2006) identifies 4-years-lag as a lagging average, highlighting that such definition varies across industries from 2 years for telecommunication and electronic equipment to 5 years for pharmaceutical industry. Comparing Chile and Finland, I opt for a 5-years-lag for one reason: Chile's R&D has been mainly concentrated on basic research funding so that considering a shorter lag period would be shrinking its actual return to R&D.

The data used are from the World Development Indicators dataset, International Labor Organization (ILO), Chilean National Commission of Science and Technology (CONICYT), Statistics Finland, and the COMTRADE database. I describe the data and their sources in more detail in Appendix A. I run the following OLSs with robust standard errors (preventing heteroskedasticity) for each country case:

$$\text{Log GDPpc}_i = \alpha 0 + \alpha 1 * I_i + \alpha 2 * L_i + \alpha 3 * RD_i + E_i \qquad [1]$$

As a second step I include the NR variable and an interaction term (RD*NR) in order to analyze the NRA effect and the relationship between NRA and R&D investment. I run the following regression again separately in each country case:

$$\text{Log GDPpc}_i = \alpha 0 + \alpha 1{*}I_i + \alpha 2{*}L_i + \alpha 3{*}RD_i + \alpha 4{*}NR_i + \alpha 5\ RD{*}NR + E_i \qquad [2]$$

In order to confirm or to reject the hypothesis 1, I compare the values of α3 of each country-case in regression [1]. To confirm or to reject hypothesis 2, I compare the values of α5 of each country-case in regression [2].

3.3 Results

The results are presented in Table 6. Regarding Hypothesis 1, in both country cases the share of R&D expenditures in GDP is positively correlated with income per capita. For the case of Chile, an increase of 1 percentual point in the ratio of R&D expenditures to GDP has increased by 29.215 percent GDP per capita. For Finland, an increase of 1 percentual point in the ratio of R&D expenditures to GDP has increased by 27.89 percent GDP per capita. For Chile and Finland the variable is significant at the 1 percent level. Hypothesis 1 is accepted.

Regarding Hypothesis 2, the interaction term RD*NR is positively correlated with income per capita in the Chile's case, whereas it is negatively correlated in the Finland's case. That would mean that in the case of Chile higher R&D expenditures would decrease the negative effect of NRA on income per capita, and that in the case of Finland a higher level of NRA decreases the positive effect of R&D expenditures. The variable is significant at the 5 percent and at the 1 percent level in Chile's and Finland's cases respectively. Hypothesis 2 is accepted.

TABLE 6 Results

	EQUATION 1		EQUATION 2	
	CHILE	**FINLAND**	**CHILE**	**FINLAND**
Investment/GDP	0.216626***	0.188143***	0.0164888***	0.0168206***
Labor Growth	-0.524572***	0.573885***	-0.4584461***	0.2665227
R&D/GDP	0.291519***	0.278951***	-3.819181*	0.47787***
Natural Resources			-.037045***	0.0107955*
R&D/GDP*NR			.0455671**	-0.0182648***
Constant	9.558367	8.939639	12.8033***	8.986311***
R2	0.9809	0.8717	0.9903	0.9131
Observations	20	20	20	20

*** significant at 1%
** significant at 5%
* significant at 10%

I undertake heteroskedasticity and multicollinearity tests. With regard to the former, the analysis suggests heteroskedasticity presence in both country-case equations; therefore I use OLS with robust standard errors. Running STATA-VIF tests, I check multicollinearity in both cases suggesting that there is no presence of it in any of the analyzed regressions. In Annex B, I present heteroskedasticity and multicollinearity tests. In the next section, I present analyses on both hypotheses results. The first part is focused on Hypothesis 1 analyzing why Chile presents a better return to R&D investment than Chile. Such analysis starts off having in mind the catching up feature of technological change and considering three factors: institutionalization, education, and decentralization. Next, I dive on Hypothesis 2, discussing what reasons might be behind the natural resources performances of each country.

3.4 Analysis

3.4.1 Hypothesis 1

Before pointing to Hypothesis 1 results discussion, I stop on the analysis of two variables considered in Equation 1: Investment Rate and Labor Growth. It is worth to note that in both cases, the return to R&D is higher than the return to physical investment. In addition, the return to physical capital is higher for Chile's case than Finland. Those results are consistent with those of Lederman and Maloney (2003) who points out that returns to physical capital investment decrease with development. Regarding labor growth, in the case of Chile the variable is negatively correlated with income per capita, whereas in the case of Finland the correlationship is positive. In both cases, the variable is significant at the 1 percent level. At first sight, we may be leaned to conclude that as Finland has a high-quality education system, with high enrollment rates and high average years of schooling, an increase in the labor force may lead to an increase in the availability of high skill workers, having the economy to its disposal a better trained manpower. Following that rational, the negative correlationship of the Chilean case may be explained by the lower quality of its educational system which would generate on average workers with lower skill than Finnish workers. Nevertheless, other factors have to be taken into account. Economic Active Population (EAP) may vary according to economy's fluctuations. As economies jump into recession times EAP may increase or decrease, since either more people starts looking for job or people get discouraged. In recovery periods, EAP may either grow pushed by an increasing amount of people looking forward getting a new job as the odds of achieving one increase or decrease as the so called “secondary” labor force returns to home. It is worth to note that in the long run EAP and economy growth may vary following the same direction but in the short term such pattern may be different. During the considered period (1981-2000), Chile and Finland went trough pervasive economical crisis: the 1982-83 recession and the early 1990s recession in Chile and Finland respectively. Therefore EAP effect might be pushed by endogenous short term factors which have to be considered analysis EAP effect on economic growth.

Back to Hypothesis 1, Barro (1991) points out that an R&D’s dollar buys greater increases in productivity for LDC than for innovating countries. Lederman and Maloney (2003) estimate R&D return rates between 20-40 percent for OECD countries; around 60 percent for medium income countries; and close to 100 percent for relatively poor countries, covering the 1960-2000 period. Previously, Goel and Ram (1994) estimate an R&D return rate of 19.6 percent for a sample of 52 nations including innovating countries and LDCs. They replicate the model by limiting the sample to 18 LDCs, estimating an R&D return rate of 41.5 percent. Therefore, the results obtained are in accordance with previous research and particularly with the central statement that a R&D dollar has a higher return in LDCs than in industrialized or innovating countries. In my model, Finland’s wealthier innovation-driven economy would be the reason of Chile’s R&D return better performance. However, we must have in mind that in order to reach its current economical and technological level Finland started out decades ago a comprehensive process involving socio, economic, and political issues leading to an increasing stock of knowledge. At this point, it is worth to bring up Helpman (2004) who notes that the transformation of Western countries into modern economies would have not been possible without the formation of institutions that encouraged the creation and accumulation of knowledge and its application to new technologies. What has been the Finland's case? According to Lemola (2003) a systemic upgrading of public policies, institutions and instruments are the seed of the R&D Finland's success. Public policies were designed aiming to meet the dynamics of not only the local but the global industry innovation demand. In addition, Dahlman et al (2005) cite education as a second pillar of Finland's success by defining it as "the key to both the supply and demand of innovation". They state that in absence of a sufficiently trained workforce new technologies hardly would be adopted or created: human capital complements technological advances. Another interesting feature of Finland's economical transformation is that meeting becoming an innovating country Finland was able of accomplishing a geographical-homogenous development. In general, high rates of economical and population concentration may become significant barriers to development, particularly for innovation nodes emergence (Castells and Hall, 1994). Finnish authorities achieved regional development by implementing strategies based on using higher education and R&D as engines of regional economic growth (Castells and Himanen, 2001).

I state an analysis of the evolution of S&T public policies in both countries aimed to identify the R&D-factors that led Finland to leave behind its natural resources dependency transforming it in an innovation-driven economy. Such pool is part of the set of causes explaining its current wealth which would justify the return to R&D model estimates with Chile's outperforming Finland's. I focus on three categories: a) Institutionalization, regarding the evolution of institutions and public policies related with S&T, b) Learning, regarding the human capital policies and their influence in S&T developments, and c) Decentralization, regarding the role of regional development in knowledge generation.

3.4.1.1 Institutionalization

Castells and Himanen (2001) points out that it would be wrong to claim that "the rise of information technology was just a result of the recession, and even more wrong to think that Finnish information-societies strategies written since 1994 have been its source". In the early 1960s, Finland's industry was mainly concentrated on natural resources exploitation and characterized by a low level of technology deterring it from having a competitive position at international markets. Therefore, catching up with more competitive economies was the main shaping force setting the S&T national system. Such task was carried out taking into account the example of more developed countries and the trade liberalization dominant trend at the time.

Lemola (2003) breaks down the S&T public policies development in three eras: a) R&D policy, b) Technology policy, and c) Innovation policy. The also called "Era of R&D Policy" covering the 1960s and the 1970s was characterized by the setting up of some of the main Finnish S&T organizations regarding planning, funding, and coordination tasks. The Science Policy Council (SPC), a ministerial committee, was created in 1963 aimed to coordinate R&D actions. In 1961, the older research councils were gathered under a central body, the Academy of Finland assuming the research funding task. The Finnish National Fund for Research and Development (SITRA) was established in 1967 to support industrial R&D. Once the laying of S&T system foundations occurred, a singular discussion on how to carry out the development Finland S&T started. Partisans of science-oriented strategy promoted strengthening the role of the Ministry of Education and its operational agencies as coordinators and funding agents, and to concentrate science development on university research. On the other hand, interested groups promoted a technology-oriented strategy highlighting the role of the Ministry of Trade and Industry. At the beginning the science-oriented trend dominated the scene; however, at the turn of the 1970s, the technology partisans gained room in the discussion leading technology to become the center concept of future S&T strategies.

During the 1980s, Finland left behind a science-oriented positions promoting technology as the core of its goals. Technology was perceived as an instrument able to raise economic growth through the emergence of the new business areas. The "Era of Technology Policy" started out characterized by an increasing government role regarding industrial innovation promotion. As an outcome of such strategy, the government decided to raise the S&T expenditures from 1.2 percent of GDP in 1982 to 2.2 percent by 1992 (Castells and Himanen, 2001). In order to meet the new-strategy goals, two key organizations were created: the National Technology Agency (TEKES) in 1983 and the Science and Technology Policy (STPC) in 1987, based on the former SPC. In addition, the decade was well-known by the creation of several technology transfer, diffusion and commercialization organizations stemming the emergence at a steady pace of spin offs and technology parks. The last phase "The Era of Innovation Policy" started at the early 1990s. The assimilation of the concepts of National Innovation System and OECD-Knowledge-based Society was the main driven of growth. Finland integrated the NIS systemic approach of innovation and in order to adapt the OECD premise created the conditions for knowledge-intensive growth by implementing measures relating to R&D, education, competitive conditions, intellectual property, national and international networks, and technology transfer and exploitation (Lemola, 2003).

Comparing the Finland S&T development with Chile's, several differences can be highlighted. Firstly, since the late 1960s Finland has had a central public organization in charge of governing and planning the S&T national system: STPC. Organized directly under the Prime Minister's authority, STPC states the major goals and tasks regarding S&T, using a top down approach to spread its decisions (Castells and Himanen, 2001). Chile lacks such type of organization. Each public agency involved sets its own planning regardless external activities. Even more, despite the inclusion in its title of the "National Commission" concept, CONICYT has not been a planning discussion organization. Its role has been restricted mainly to funding tasks. It is worth to note that as an outcome of the discussion on the allocation of funds coming to S&T tasks from a new mining tax, a National Innovation Council for Competitiveness (CNIC) integrated by public, private and academic agents has been recently created. However, it would be advisable that CNIC's role goes beyond the mining tax funds allocation discussion, covering issues such as the Chilean S&T system governance and even more assuming an STPC role alike; otherwise current problems such as duality in funding and task allocation, and lack of homogeneity in the decision-making research area process will not be completely overcome.

Secondly, in general, the S&T public supporting structure has been set up much earlier in Finland than Chile. Organizations such as SPC, Academy of Finland and

SITRA were established in the 1960s. In the case of Chile, only CONICYT was created at that time, and its first significant fund, FONDECYT, was just established in 1981, and aimed to just fund basic research activities. Regarding technology institutionalization, despite its main boost started in the late 1970s, especially with the creation of Tekes, several prior policies had defined it as one of the main public agencies targets. In the case of Chile, the advent of democratic government in the early 1990s was the main technology-policy driven. The launch of several technology-oriented-publicly-funded programs was accompanied by a reorientation of CORFO's goal. Since the early 1990s CORFO has been the main promoter of technological development at the firm level in Chile, leaving behind its prior industrialization promoter role. Comparing only the setting dates of the public organizations involved in NIS, including the reorientation of preexisting agencies, there is a significant delay in the Chilean case regarding Finland.

Thirdly, as part of the NIS, and as it was mentioned before, Chile lacks significant private investment in innovation. Only a 33.2 percent is funded by the private sector, contrasting with the 70.8 percent of Finland, and the OECD average of 65 percent. According to CNIC-C (2006), such performance is an outcome of the scarce relevance attributed to innovation within the firms' strategy, and to the innovation absence in their productive routines. Such rational is in part related with the commodities-intensive productive structure dominant in Chile, which deters the country from added-value-chains. Even though Chilean firms well-perform regarding "soft" innovation related with management tasks, "hard" innovation has not been a common target in Chilean firm practices. Such premise has led to lack of innovation culture which is reinforced by several factors at the firm level: low availability of venture capital; scarce presence of individuals with technological innovation management capacity; insufficient information regarding public innovation supports; and the weak firm interaction at cluster level (CNIC-C, 2006). Such situation diverges from Finnish policy of incentives. Tekes has fully assumed its funding research task for which it has been recognized at the international level (Castells and Himanen, 2001). According to Schienstock (2005) one of the most effective ways to improve the quality of research in Finland has been increasing the share of competitive funds. Besides, SITRA has evolved from a funded technology research task to a venture capitalist role aimed to finance the beginning and expansion of start-up companies that have already received research funds from Tekes.

3.4.1.2 Education

According to Maloney (2002), learning capacity is built over national human capital performance and the networks of institutions that facilitate the adoption and creation of new technologies. I focus my analysis on variables regarding human capital capacity by breaking down the analysis into three categories: literacy, primary and secondary enrollment, and tertiary enrollment.

Since the nineteenth century, Scandinavian countries have followed a tradition of high literacy rate. Finland has not been the exception: almost 89 percent was literate in 1890 (O'Rourke and Williamson, 1995). In contrast, Chile inherited from its Spanish colonizers, a rentier and low-entrepreneurial mentality which led to both a high concentration of wealthy individuals and high rates of marginalization affecting the access to education: Chilean literacy rate was barely 30.3 percent in 1890 (Engerman et al, 1997). Despite its significant increase over the years (literacy rate reached 95.8

percent in 2002) the earlier low Chile's literacy performance represented a serious disadvantage.

Regarding primary and secondary enrollment rate, both countries have reached high levels during the last decades. Firstly, both countries have attained gross enrollment rates of primary education above 100 percent in 2004: 101 percent in Finland and 104 percent in Chile. Worth to highlight is Chile's behavior regarding gross enrollment rate of secondary education, jumping from 53 percent in 1980 to 89 percent in 2004. Such increase was based on strong coverage policies undertaken during the 1990s with the advent of democratic governments. However, despite of such progress, Chile's educational system still presents several quality disadvantages regarding Finland's. Chile's performance in the Third International Mathematics and Science Study (TIMSS) of students was poor ranking 35th among 38 countries in both categories math and science, whereas Finland ranks at 14th and 10th positions respectively (TIMSS, 1999).

The tertiary education enrollment presents the most significant difference. At the early 1980s, Finland had a gross tertiary enrollment of 32 percent which increased up to 90 percent in 2004. During the same period, Chile started at a low 12 percent, attaining in 2004 a 43 percent rate, mainly boosted by the emergence of private-funded universities. Among tertiary students the Science and Engineering (S&E) enrollment rates score at similar levels: 31.4 percent for Chile, and 38.2 percent for Finland. I highlight such statistic due to the S&T input category of S&E graduates. Most of them will work on either technological development issue or knowledge creation, and some of them will be part of the S&T national community. In that sense, the number of researchers in both countries has increased during the last decades but at different pace. The number of researchers in Finland has seen an increase of almost threefold during the 1983-2001 period whereas in the case of Chile, the increase was by 52 percent[24]. Furthermore, Finnish researchers have a major likelihood to work in the private sector than their Chilean colleagues: 30 percent of them jump into local firms whereas just 6 percent do it in Chile (Tokman and Zahler, 2004).

In 1981, the OECD made a review of Finnish educational policy recommending carrying out a thorough polytechnic reform, which was rejected by the Finnish authorities at the time arguing that such proposal was out of the national targets therefore an allocation of resources was not feasible (MINEDU, 2004). However, later on MINEDU restudied the OECD proposal, and decided to launch a Vocational Education and Training (VET) reform which would include not only the establishment of polytechnics but also a strong cooperation between upper secondary schools and post-comprehensive vocational schools (MINEDU, 2004).

In 1991, the Finnish Parliament enacted the beginning of the VET reform. Following this legislation, 22 polytechnics were set up across the country, merging the 250 VET's schools existing at the time according to disciplinary and regional criterias (MINEDU, 2004). The new polytechnics have undergone rapid growth. Between 1992 and 1999 the number of applicants and the number of first-year student rose fourfold and fivefold respectively. It is worth to note that 89,700 people applied for 24,040 places in 2000. However, the most impressive increase regards the total number of polytechnic students, which have risen twentyfold since the early 1990s (Kekkonen, 2005).

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[24] CONICYT Indicators, www.conicyt.cl

3.4.1.3 Decentralization

According to Kautonen et al (2005), Finnish regional innovation systems successfully implemented have afforded GDPs 20 percent higher than the national performance for those regions over the 1995-1999 period. However such success has been paved over two main development factors: human capital and institutions. Regarding human capital, the National Government aimed to prevent a high concentrated supply of high skill workers by implementing, from the 1960s onwards a network of regional universities with emphasis on engineering and technology. Before that, only Helsinki and Turku had full universities. Castells and Himanen (2001) cites several Finnish regions as examples of regional development regarding the technological university settlement: Tampere, where two universities played a major role in the implementation of the Tampere's information cluster; Oulu, nowadays an ICT pole which has transformed the region in the fourth major metropolitan node in Finland; Rovaniemi, where setting up a new technology-oriented university was the key for the revival of high value-added industries, and Lappeenranta, where the process of growth was clearly associated with the presence of a new technology-oriented university. The polytechnic reform started in the early 1990s, with a clear homogenous-development criteria, has been the "second wave" of this technology-regional-oriented educational reform by covering the demand of high skill workers able to participate of high tech production process. Regarding institutions, the national government undertook important reforms. First, a reduction of the number of administrative districts was implemented looking for a lower bureaucracy and higher capacity to shape more fitted regional innovation policies (Schienstock, 2005). The Center of Expertise Program (CEP) was launched in 1994 aimed to improve knowledge base by focusing on regional strengths and by promoting joint-multidisciplinary project. In addition, Ministry of Trade and Industry, Ministry of Labour and Ministry of Agriculture jointly combined their regional efforts in the Employment and Economic Development Centers (EEDC) at the regional level. Fifteen centres countrywide has been settled providing a comprehensive range of advisory and development services for businesses, entrepreneurs, and private individuals. Both types of factors have contributed to the emergence of technology parks throughout Finland taking advantage of public incentives and well-trained manpower.

With regard of the Chilean case, I organize the analysis in two points. Firstly, Chile historically has been a concentrated country in terms of population and political and economical power. Nowadays, forty percent of the population lives in Santiago[25], the national capital, whereas just 18 percent of Finnish population lives in Helsinki[26]. Despite some governmental initiatives and the Regional Reform launched in 1992, Chilean political and economical powers are mainly concentrated in Santiago. Secondly, regarding innovation activity, the centralization persists: 50 percent of the Chilean researchers work at the capital and 60 percent of the FONDECYT, FONDEF and Technological Development National Fund (FONTEC) budgets have been allocated to projects presented in the Metropolitan Region during the 1990s (Academia Chilena de Ciencias, 2006). In addition, despite the successful examples of the fruit, salmon and wine industries (Giulani, 2004), the concept of technological cluster have not reach its maximum potential (World Bank, 2003). In the emergence of the Chilean clusters already

[25] Instituto Nacional de Estadisticas, Chile, www.ine.cl
[26] Statistics Finland, www.stat.fi

mentioned, there was an active participation of public agents, and technology transfer institutions such as Fundacion Chile as support organizations. However, before both the CORFO's initiative of the upper 1990s and CONICYT's regional knowledge programs launched in 2001, Chile has not promoted or implemented a steady regional knowledge generation policy such as Finland did which would lead to a more homogenous development through the emergence of development poles along the country.

3.4.2 Hypothesis 2

In order to analyze Hypothesis 2, it is worth to bring up De Gregorio and Bravo-Ortega (2005) who point out that economies with rich endowments of human capital and close linkages between natural resources and industrial activities can formalize "the idea of the joint development of an industrial or high-technology sector simultaneously with natural resources". They highlight the case of the forestry industry in Scandinavia where the development of natural resources was accompanied by the growth of an industrial base linked to the forestry sector. So, one way to offset any possible negative effect coming from a natural resources dependency may be the emergence of new technology-based industries whose emergence would be conditioned by both having high-skill manpower and high rate of R&D investment. Such phenomenon would afford not only a reinforcement of natural resource industries but also the establishment of new industries which may lead in the long term to significant modifications of the current productive structure. According to Dahlman et al (2005), the diversification of export portfolio has been mandatory to the improvement of Finnish economy stemming from a steady promotion of higher education, linkages and spillovers among industries, and the spawn and spread of new knowledge-based industries. Dahlman et al (2005) traced back into

Finnish knowledge-based economy evolution by establishing its roots into user-producer linkages between forestry-based firms as user of high technology, and the emerging engineering, electronic and ICT industries in the 1960s. They analyzed the economic development of Finland by breaking it down in three chronological phases and by identifying their major features regarding technology-behavior and product-type (see Figure 14). Chile's case is different. The consolidation of Chilean natural resources industries has not been accompanied by the emergence of knowledge-based industries capable to supply them with intermediate or input products. The human capital richness and high R&D budget conditions are not fulfilled in the Chilean case, therefore natural resources-based industries are still constraint to low added-value products. Such situation contrasts drastically with Finland's industrial evolution where natural resources based industry were not only complemented by high tech industry but also were part of the market forces pushing for the latter's spawn and boom.

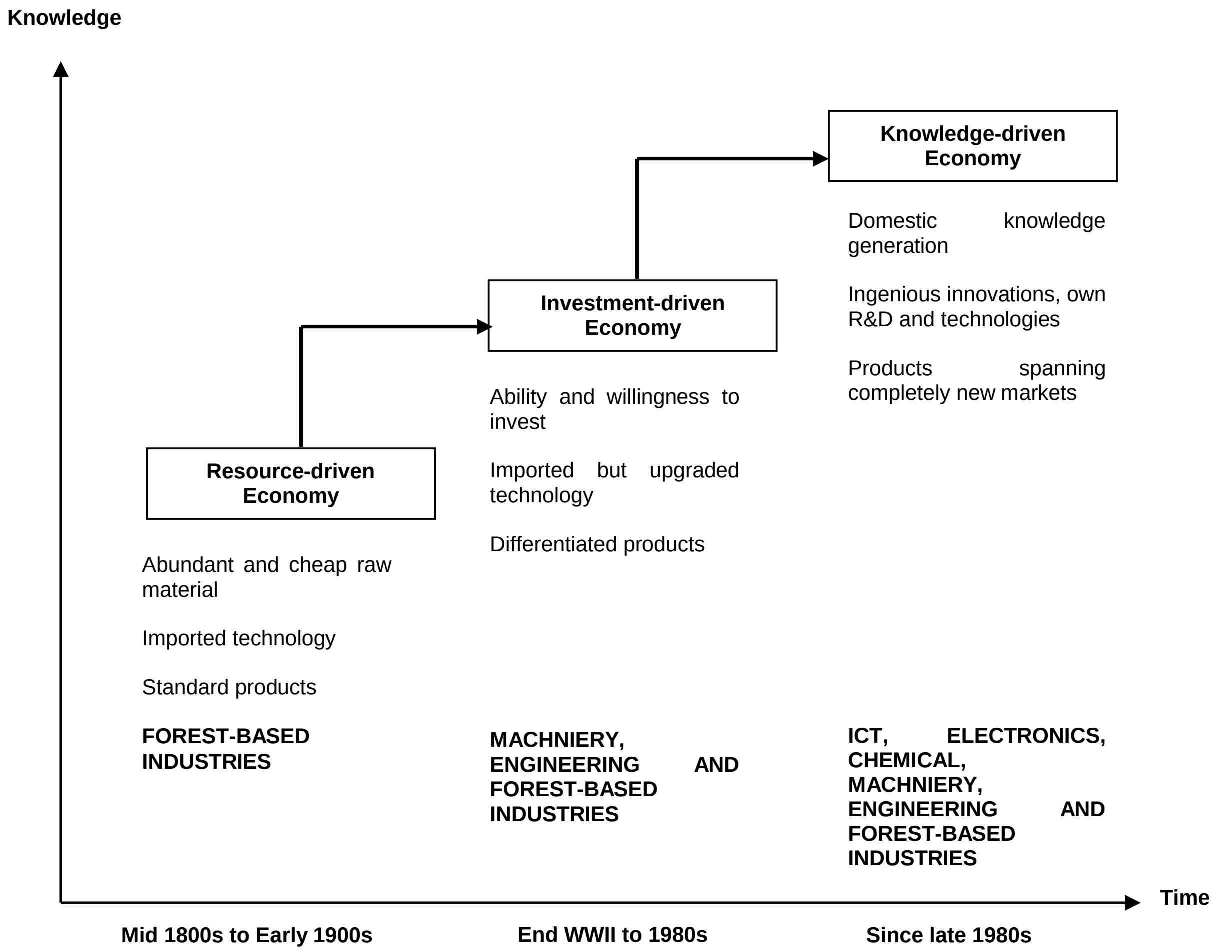

Figure 14 Finland's Stages Industrial-Economic Development
Source: Dahlman et al (2005)

Backing to Equation [2] results, an increase of 1 percentual point in the share of natural resources exports in total exports has increased by 1.07 percent Finland's income per capita. The Finland's higher and positive return to NRA is justified by its high R&D and education performances. As Finland opened its economy during the Post WWII period, its exports started to be subject to higher quality standard requirement. The challenge was addressed promoting technology creation and diffusion at the production level. In addition, by means of delivering better educational training, Finland's workforce became a high skill one, able to participate in the industrial challenges of the knowledge economy. Finland's natural resources endowment has not been a barrier to development; quite the contrary, it has been an important catalyst, not only regarding its own activity, but also pushing the emergence of new high-tech sectors. In the case of Chile, an increase of 1 percentual point in the share of natural resources exports in total exports has decreased by 3.70 percent Chile's income per capita. Therefore, Chile's return to NRA is not only smaller than Finland's but also negative. As I mentioned before, having low human capital performances and a low innovation capacity has deterred Chile from jumping into the knowledge economy postponing a high-tech industry spread. The strong natural resources dependency has not been left behind, and its consolidation has not been accompanied by the establishment of "lateral" industries able to supply them with high-tech inputs. Therefore, for Chile's case NRA has had a negative effect on economic growth but it has to be mentioned that NRA has not put Chile away of a steady growth path particularly during the last two decades.

Analyzing the interaction term coefficient gives us interesting insights on the evolution between R&D and NRA. Return to NRA has increased with R&D by 4.5 percent and has decreased by 1.8 percent in Chile and Finland respectively. The fact that Chile's coefficient is greater than Finland's may be contradicting the previous analysis on NRA effect on development. However, the explanation may be on the differing R&D capacity. As Chile R&D capacity is low and its dependency on natural resources high, an increase on R&D investment decreases the negative NRA influence, or in other words the returns to NRA rise with R&D. R&D offsets the NRA's negative effect on economic growth. Those results are in accordance with those of Lederman and Maloney (2002), and De Gregorio and Bravo Ortega (2005). The same effect is not only smaller on

Finland, but even negative. The negative performance on the interaction term means that as NRA increases the positive return to R&D decreases. The explanation may be on the high R&D capacity and on the lower NRA dependency. Finland's economy is nowadays moving towards a much higher high-tech exports share becoming a much more knowledge-intensive economy. Such process has afforded a much higher economic productivity and a much higher R&D concentration on high-tech industry[27]. So, as NRA-dependency has been left behind, turning back to it would decrease the return to R&D since the economy would have been more concentrated in other areas with much higher R&D return. Summing up, the pattern of the R&D and development relationship may be partly replicate with R&D and NRA: a dollar invested in R&D in a NRA-country closer to the technological frontier would have a smaller effect than in NRA-countries with low innovative capacity on decreasing the plausible NRA negative effect on economic growth since innovating countries must invent the new technologies that push the frontier forward. On the other hand, NRA-countries with low R&D capacity would be able to decrease the NRA negative effect by catching up to the technological frontier.

[27] Nokia's R&D investment represents 30 percent of national R&D investment (Blomstrom et al, 2002)

CHAPTER 4

CONCLUSIONS

NRA has not been a barrier to Finland's economic development, and has not deterred Chile from a successful growth path during the last decades. However, Finland's better economical performance lays on a different base that Chile's. At the mid-twentieth century, Finland opened its economy leading to a request for high standard products. Addressing such demand, Finland reformulated its development strategy affording a significant change in its productive structure by boosting an new high tech industry. On the other hand, Chile has laid its growth over two main pillars: trade liberalization and an economic and institutional regime characterized by the strength and transparency of its public institutions. However, Chile has not been able of modifying its productive structure as Finland did, remaining as a low-added-value-good producer.

From my analysis, that the return to R&D is higher in Chile than Finland. An increase of 1 percentual point on R&D investment has increased by 29 and 27 percent income per capita in Chile and Finland respectively. Chile's better performance has to be analyzed taking into account that countries far from the technological frontier reap greater benefit from each dollar invested in R&D than those closer to it. Therefore, Chile's R&D coefficient higher value is not an indicator of Chile overcoming Finland but of the latter's wealthy and particularly higher innovative capacity. I argue that the reasons behind such diverging performance lay on the base of Finland S&T reform. The answer is not just related to the increase of S&T expenditures at the national level, but to a set of other factors. Human capital endowment, strong public institutions and leadership, S&T-promoting public policies and the establishment of technological cluster at the regional level have contributed to shape an environment able to supply the right incentives in order to promote technological investment not only at the public but also at the private level. However, it is worth to note that such environment did not emerge at the post-recession time at the early 1990s. It was the final result of a dynamic process started decades ago with the genesis of the current human capital endowment and the setting of a group of public institutions. Besides, Finland has adopted as its own both the National Innovation System and the OECD-Knowledge Based Society approaches which has led it to assume a innovation systemic and synergic profile

With regard to natural resources, I explained the higher Finnish return to NRA in light of the historical development of the Finland's natural resources industry. Finnish NRA firms were not devoted exclusively to natural resources exploitation and the subsequent production of low value-added goods. They aim to produce their own inputs in order to lower their production costs. However such phenomenon is based on an underlying synergy not replicated in the Chilean case. Finland since the nineteenth century was a country with a rich human capital endowment so that high skill workers were available to immerse themselves in the creation and the adoption of new technologies. In addition, the Finland's historical economic openness afforded the introduction of higher level of market competence and the acquaintance of new technological development. On the other hand, Chile presents a better performance than Finland on how R&D and NRA have complemented each other. Chile's return to R&D rises with NRA, since NRA industries are Chile's most important economical activities, whereas Finland's decreases as NRA is not the main local economical activity. In addition, I suggest that return to R&D and development negative correlationship may be replicated on return to R&D and NRA just limiting the analysis to NRA countries. The richer and more innovative the country, the less the return to R&D rises with NRA. I would apply the same rational than the return to R&D and development analysis: an R&D investment has a lower return in wealthier and innovating country than in LDCs since the former are closer to the technological frontier therefore they are the main pusher of it, whereas LDCs reap benefits just catching up to the frontier. Regarding the relationship of NRA and R&D I propose as a future research area comparing the evolution of a specific natural resources industry in both countries. Such analysis should be concentrated on innovation issues, being a good instance the case of the Forestry Industry, since both Chile and Finland have strong local forestry developments.

In order to contribute to the current discussion I bring up some proposals in terms of Chilean S&T development regarding some Finland's lessons. Firstly, *to increase the quality and access of the national education system and to promote science and engineer careers*. Chile has increased its rates of primary, secondary and tertiary education but such success has not been accompanied by the supply of high quality education yet. Low income families have just access to public education whose quality level is significantly lower than private education. In addition, whereas Finland implemented a regional network of technology-oriented universities, new Chilean universities are mostly concentrated on graduating social science professionals, postponing science and engineering careers in light of their high costs. S&T teaching (specially at the graduate level) and research activities have to be promoted among the new network of private universities. Furthermore, the low share of polytechnic-graduated professionals in Chilean labor market contrasts sharply with their high supply and demand in Finland. Such supply constraint of S&T professionals damages not only the number of researchers in academia but also in industry. The low number of S&T graduates working in industry is a serious risk for Chilean innovation performance since it may limit not only the development of new either product or process but the definition of future business area. Second, *to modify the current institutionalization ruling the Chilean S&T system by building a centralized and participative S&T government able to define the major strategic Chile's S&T research areas*. Nowadays, Chilean agencies involved in S&T management are not ruled by a common national authority contrasting with the Finnish S&T system governed by STPC since the 1960s. A coordinated work of the S&T Chilean agencies may bring up a better productivity of the S&T system since innovation may be generated using a systemic approach in which public-private partnership would be the main support. Such process should start by settling a National Council of Science and Technology with equal participations of public, private and academic actors supporting the generation of knowledge aimed to increase national competitiveness. Third, *to promote regional innovation cluster looking for an S&T homogenous national development*. The Finnish example shows how the impact of decentralization policies may be upon economic development. A network of technology-oriented universities strengthened with several promoting-development-oriented regional organizations settled by the national government has generated income levels higher than the national average. In the case of Chile, EEDC or CEP-institutions-type has to be promoted in order to link the R&D university activities with the market demand at the regional level. Through such kind of organizations, scientists just concentrated on the

S&T development but working in previously defined increasing-competitiveness research areas.

In conclusion, Finland's success is explained by the conjunction and steady upgrade of several factors: institutionalization, learning capacity and decentralization. Chile is bridging the gap nowadays, launching several public-funded initiatives aimed to increase public S&T expenditures, promote private S&T investment, the establishment of technological clusters, and the improvement and increase of human capital stock. Furthermore, a major discussion regarding S&T public governance is occurring in Chile which has led to the proposition of a new institutional framework. In general, despite the cross-country differences, *Chile is following today a relatively similar path that Finland started decades ago*, and as Chile's Minister of Economy has pointed out "…Chile has already consolidated trade liberalization, where competitiveness is essential…".[28]

[28] Chile's Minister of Economy, Alejandro Ferreiro, El Mercurio March 10th, 2007

APPENDIX A

DATA SOURCES

a) Dependent Variable

-GDP per capita (GDPpc): World Development Indicators, The World Bank
Real GDP per capita series,
2000 Constant Price

b) Independent Variables:

-Investment rate (InvGDP): The Penn Tables version 6.1
Investment Share of Real GDP
1996 Constant Price

-Labor growth rate (Laborgrowth): International Organization of Labor, LABORISTA dataset.

-The share of R&D expenditure in GDP (R&D/GDP):
Chile: CONICYT dataset
Finland: OECD Main Science and Technology Indicators

-The share of natural resources exports in total exports (NR): UN COMTRADE

Natural Resources Exports

Exports of Fuel: Comprise commodities in SITC Revision 1, Section 3 (mineral fuels and lubricants and related materials).

Exports of non fuel primary products: Comprise commodities in SITC Revision 1 Section 0,1,2,4 and 68 (food and live animals, beverages and tobacco, inedible crude material, oils, fats, waxes, and non ferrous metals).

APPENDIX B

REGRESSION TESTS

a) Equation [1]

a.1 Heteroskedasticity

-Chile

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of loggdppc

         chi2(1)      =     1.12
         Prob > chi2  =   0.2903
```

$Chi_2(1)$ at 5 percent confidence level=3.84
1.12<3.84
Ho is rejected, then heteroskedasticity

-Finland

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of loggdppc

         chi2(1)      =     0.05
         Prob > chi2  =   0.8233
```

$Chi_2(1)$ at 5 percent confidence level=3.84
0.05<3.84
Ho is rejected, then heteroskedasticity

a.2 Multicollinearity

-Chile

Variable	VIF	1/VIF
invgdp	2.48	0.403193
laborgrowth	2.07	0.482044
rdgdplag5	1.58	0.631430
Mean VIF	2.05	

Mean VIF=2.05
2.05<6, then No multicollinearity

-Finland

```
    Variable |       VIF       1/VIF
-------------+----------------------
   rdgdplag5 |      1.88    0.532190
      invgdp |      1.88    0.533037
 laborgrowth |      1.02    0.976568
-------------+----------------------
    Mean VIF |      1.59
```

Mean VIF=1.59
1.59<6, then No multicollinearity

b) Equation [2]

b.1 Heteroskedasticity

-Chile

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of loggdppc

         chi2(1)      =     1.14
         Prob > chi2  =   0.2858
```

$Chi_2(1)$ at 5 percent confidence level=3.84
1.14<3.84
Ho is rejected, then heteroskedasticity

-Finland

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of loggdppc

         chi2(1)      =     0.00
         Prob > chi2  =   0.9486
```

$Chi_2(1)$ at 5 percent confidence level=3.84
0.00<3.84
Ho is rejected, then heteroskedasticity

b.2 Multicollinearity

-Chile

Variable	VIF	1/VIF
nr1	7.13	0.140258
laborgrowth	3.61	0.276876
invgdp	3.29	0.304330
rdgdplag5	2.11	0.473392
Mean VIF	4.03	

Mean VIF=2.05
4.03<6, then No multicollinearity

-Finland

Variable	VIF	1/VIF
rdgdplag5	10.18	0.098210
nr1	7.36	0.135793
invgdp	2.34	0.427379
laborgrowth	1.13	0.888849
Mean VIF	5.25	

Mean VIF=2.05
5.25<6, then No multicollinearity

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